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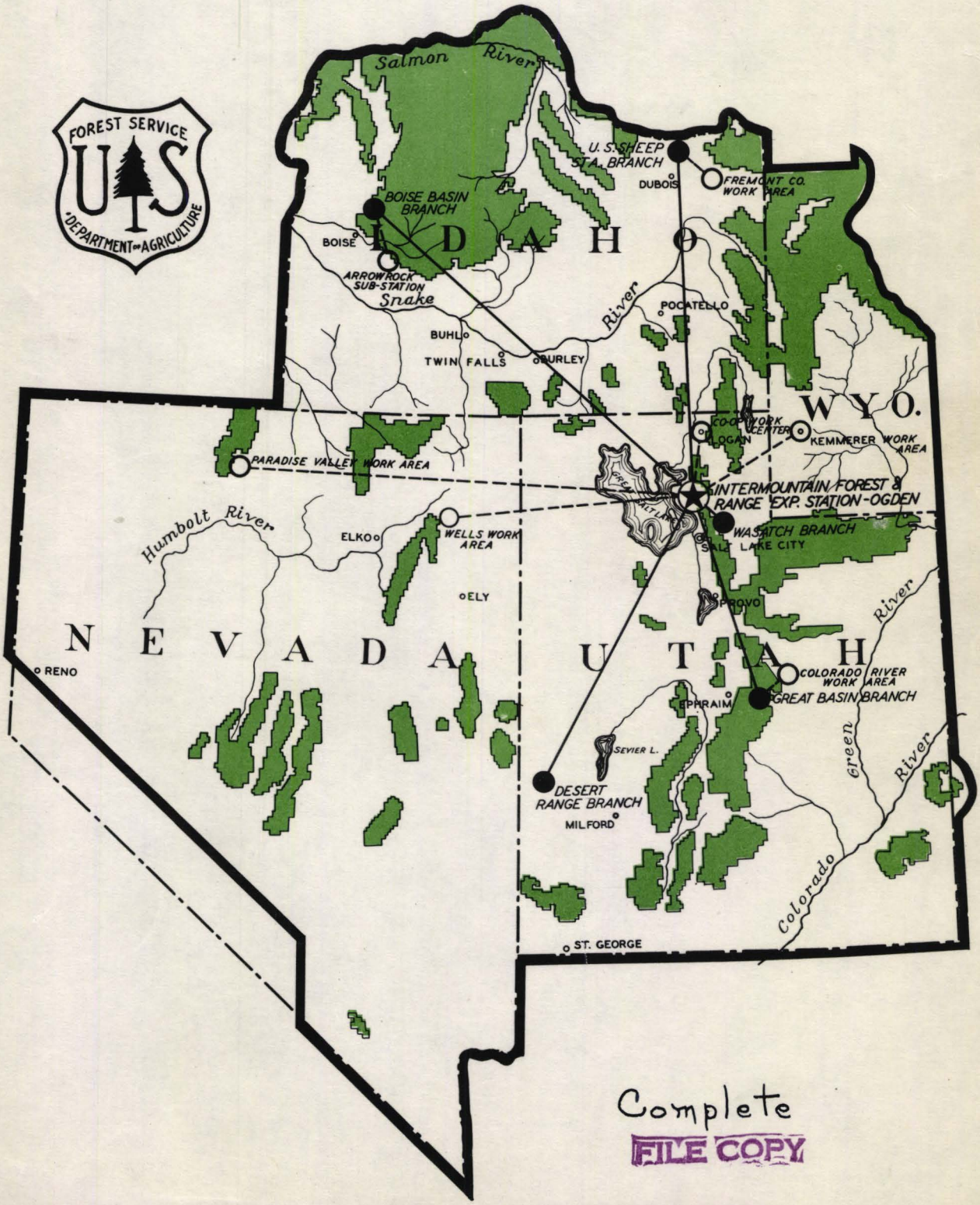
1937 ANNUAL INVESTIGATIVE REPORT

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION



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B.F.T.

"SEARCH FOR TRUTH IS IN ONE WAY HARD AND IN ANOTHER WAY EASY, FOR IT IS EVIDENT THAT NO ONE CAN MASTER IT FULLY NOR MISS IT WHOLLY, BUT EACH ADDS A LITTLE TO OUR KNOWLEDGE OF NATURE, AND FROM ADL THE FACTS ASSEMBLED THERE ARISES A CERTAIN GRANDEUR."

--ARISTOTLE

R - INT
Investigative Program
and Report

PREFACE

Nearly a half century has elapsed since the utility of wild land resources — timber, forage, and water — received its first real recognition. That this acknowledgement lacked unanimity and popularity was attested by the howls of public protest that attended President Cleveland's proclamation setting aside the thirteen original "forest reserves." In the intervening years hostile sentiment has subsided and public attitudes have undergone the gamut of metamorphoses from antipathy and apathy to regard and respect; and not the least of the factors occasioning change has been the slow realization on the part of the people themselves that the ends sought through creation of the so-called "reserves" were neither chimerical nor hurtful; were not aimed at excluding use of forest and range; but were intended primarily for protection of these lands, and for integration and maintenance of various uses in perpetuity in the interest of public good.

Today, as never before, the people of the Intermountain country are recognizing that their security and welfare in large measure is dependent on the sustained utility of the interrelated resources of wild lands — water, forage, and timber. An awakening, if it may be regarded as such, is evinced in the sane, dispassionate, and voluntary appraisal of wild land problems by civic groups and civic-minded citizens; in the acquisition and donation of watershed lands to national forest ownership; and in the increasing interest and support of programs aiming to restore and maintain wild lands at full resource productivity. This growing consciousness, like the radiant hues of sunrise, is a reassuring sign.

To the Forest Service charged with administration, protection, and rehabilitation of some 30 million strategic acres (cf. green portion of map on cover) this public approbation is both a tribute and a challenge; a tribute to the skill and integrity of its personnel in the steadfast prosection of difficult programs; a challenge to new and greater achievements in public service. That the Forest Service will shoulder unflinchingly the heavy responsibility of protecting and rehabilitating gutted lands there is no doubt; that it will need whole-hearted public support in the efforts to accomplish these objectives there can be no question.

The role of research in this Service program of rehabilitation and judicious sustained use of all wild land resources is both important and large. For there is no magic in federal forest ownership, per se. Mere transfer of lands into national forest status automatically does not cause silt-laden streams to run clear again nor barren hillsides to grow verdant with a lush cover of forage and timber; what it does provide is intensive protection, which though a long and fundamental step toward rehabilitation is often not sufficient to induce a reasonably rapid and effective reversal of the abusive processes that have destroyed the balance of Nature's budget. The work of restoring wild lands to acceptable levels of productivity and of their maintenance through prescription of safe limits of use requires abetment by the trained intelligence of research.

To this end the Intermountain Forest and Range Experiment Station is directing its research program, the broad features of which include (a) the diagnoses of problem areas; (b) the formulation of restorative methods; (c) the determination of safe limits of resource use; and (d) the deduction of underlying laws and principles that govern the complex interrelationships of biologic elements in a physical environment. In the discussions that follow, some attempt has been made to depict in broad panoramic sweeps the past use of forest, range, and watershed lands, the problems arising from such use, and more specifically, to point out what the Intermountain Station is doing to solve the problems of wild land use and restoration. Against the background of myriad problems the current accomplishments may appear insignificantly small; but it should be remembered that "each adds a little to our knowledge of Nature, and out of all the facts assembled" there will arise not only "a certain grandeur" but also the basic principles that will enable the administrators of wild lands, both public and private, to cope effectively and efficiently with the problems that have arisen from past abuse or may arise from present and future use of such lands in order that the full benefits from forage, recreation, timber, water, and wildlife may accrue to the people of the Intermountain West.

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THE INTERMOUNTAIN REGION

The Intermountain region (Region 4 of the Forest Service) comprises all of lower Idaho south of the Salmon River, all but ten million acres of Nevada, the entire State of Utah, and western Wyoming. Pertinent data on acreages, etc., are given in the table below.

State	1/Area of portion in Region 4	Net area of National Forests	2/Approximate area of public domain	3/Approximate area in other ownership	Percent in Nat'l Forests	Approx. percent in public domain
	Acres	Acres	Acres			
Idaho	41,600,542	13,315,542	8,902,000	19,383,000	32.1	21.4
Nevada	60,485,025	4,444,025	44,255,000	11,786,000	7.4	73.2
Utah	54,394,294	7,624,294	25,157,000	21,613,000	14.0	46.2
Wyoming	12,480,471	3,883,471	3,036,000	5,561,000	31.2	24.3
TOTAL	168,959,332	29,267,332	81,350,000	58,343,000	17.4	48.1

1/ Only Utah is entirely within Region 4 boundaries.
2/ Unreserved, unappropriated lands.
3/ Includes private, state, county, municipal, national parks, national monuments, and Indian lands.

On the cover of this report is a map of the region showing principally the distribution of national forest lands and the location of the primary work centers of the Intermountain Forest and Range Experiment Station. The location of the branch stations and work areas is predicated largely on location of areas of acute problems with regard to range, timber, and watershed functions of wild lands. While the major part of the intensive research work is conducted at the branch stations and other work centers, the station aims to serve the entire region. The present forces and facilities are, however, inadequate to carry out the investigative program in all urgent problem areas of the Intermountain region.

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Investigative Program
and Report

THE INTERMOUNTAIN RANGE LANDS: A VAST PROBLEM AREA

Within the Intermountain region forage produced on 145 million acres of range land forms the basic resource upon which the livestock industry is built, an industry contributing approximately 30 percent of the direct agricultural income to the welfare of the region. This industry is the donor of the life blood that lends and promotes economic permanence not only to local enterprises in the 60 supply towns and larger trade centers, but to regional business as a whole. Curtailment of or injury to the forage resource is instantly reflected in the welfare of the communities directly dependent upon the livestock industry for a livelihood. Not only does the fate of the livestock industry hang in balance with sustained usable forage production, but the attendant multiple uses of the land--water, wildlife, and recreation--also depend on the continued productivity of the forage resource.

Diaries and accounts of the early explorers and fur traders are testimonials to the original productivity of Intermountain ranges. These range lands may never have been a "uniform waving sea of grass belly deep to a horse", as compared to the midwestern tall grass prairies, nor were they unmarred by unproductive scabland areas. But fragmentary evidence from a relatively few relic areas (fence corners, cemeteries, railroad rights-of-way, or inaccessible areas) scattered throughout the region indicate that the Intermountain range lands, despite the forbidding areas upon which early explorers could scarce find feed for their horses, under existing climatic conditions and in their virgin state, might well have been capable of furnishing forage for two to three times the 5 million sheep and 1 million cattle that now feed upon them from 6 to 12 months of the year. Not only may this marked contrast in productivity have been true under virgin protected conditions, but range lands of some progressive livestock men and some public ranges under administration have demonstrated that under use, proper management might have perpetuated the original forage resource practically intact.

Native range lands of the Intermountain region may be divided roughly into four very general vegetative types: salt-desert shrub, sagebrush-grass, pinyon-juniper, and open forest. These types under past grazing practice and existing climatic conditions have become associated with definite seasonal periods of grazing. As such, each type in furnishing forage during some season forms one link of a chain in the year 'round feed supply for the livestock industry. The salt-desert shrub has become associated with winter use. Pinyon-juniper and sagebrush-grass types

characterize the spring-fall ranges of the region, and the open forest type completes the chain by supplying the forage for the summer grazing period. Obviously the stability of the livestock industry is dependent in a very material way upon maintenance of the forage of each of these types.

Grazing on the Intermountain ranges beginning with the advent of early settlers proceeded in a haphazard fashion. Lavish use of natural resources, even though typical of early American development, counteracted to some extent by attempts here and there at trial and error range management, soon began to take a toll in forage productivity. Individual livestock operators in many cases were forced by unsound public land policy and financial handicaps to overutilize their ranges severely. Continued misusage of many public ranges had as early as 1900 resulted in serious depletion. Then during the period 1931 to 1935 increased livestock numbers resulting from economic unrest and low forage yield resulting from drought produced an overload on all ranges. Overutilization of already weakened plants resulted in mortality for many of the more relished plant species. It was during this period that the range suffered a shock from which it has not yet fully recovered.

In their present plight many ranges no longer produce the abundance of valuable grasses they once did. Forage plants possess only 20 to 80 percent of the vigor they normally had and in many areas of the greatest livestock concentration nearly half the plants are dead. The widespread mortality of valuable native plant species, together with reduced herbage production of the live plants as a consequence of lessened vigor has resulted in a greatly diminished plant cover. In many depleted areas vacated spaces have been occupied by aggressive species of low-forage value. On other areas depletion has been so complete that extensive soil losses have occurred, rending the sites unfavorable for the species formerly occupying the area.

On salt-desert shrub winter ranges, although only a moderately productive type even in its pristine condition (nevertheless furnishing forage for several million sheep in Utah, Nevada, and Wyoming, during the winter periods) valuable shrubs and grasses have been extensively replaced by much less valuable perennial and annual species, either worthless for forage or highly unstable in productivity. Valuable white sage and ricegrass, over large range units, have given way to matchbrush and desert rabbitbrush. On other areas depletion has been accompanied by the encroachment of Russian-thistle.

On the sagebrush-grass type, largest single range type within the Intermountain region, destruction of native bunchgrasses over extensive areas has been accompanied by a thickening of the sagebrush stand, or where injudicious burning and grazing have been practiced, by replacement with downy chess and Russian-thistle. Accompanying this deterioration vast areas of native sagebrush-grass

range, highly productive but marginal for dry farming, were broken and placed in wheat production. Instability of rainfall rendered crop production unreliable and on extensive dry-farm areas even the hardiest homesteader was forced to abandon the land. Following abandonment, unrestricted usage prevented even the normal slow revegetation of the land by valuable forage species until now approximately 5 million acres of potentially productive land lie clothed only by annual and perennial species of little value. These lands not only fail to lend materially to the forage resource of the region but they form wind and water erosion hazards and harbor such farm pests as the beet leafhopper.

Depletion on the pinyon-juniper type has been accompanied by a general thinning of the herbaceous understory with some increase in density of the tree stand.

On the open forest type, used primarily for grazing during the summer period and potentially the most productive of the native range types, forage depletion has resulted in the replacement of good forage plants by inferior species and in the general thinning of stand. Since the open forest type, typically occupies mountainous areas of rough topography, thinning of the vegetational protective covering is followed by wasting away of the soil through erosion. Mountain meadows and types adjacent to stream courses have become distinct problem areas since through deterioration stream courses have become channeled by erosion and debris deposited on productive valley lands below.

Approximately 112 million acres, roughly 80 percent of the range area, is in need of immediate measures of rehabilitation. These ranges, having suffered a severe setback in grazing capacity and clothed by inferior protective covering, are rapidly losing valuable topsoil. In many areas depletion has been so severe as to permit virtual destruction of the vegetational protective covering with the resultant channeling of stream courses by erosion. Not only has soil been removed and valleys trenched but the scenic beauty of the land as been marred as well as rendered less favorable to production of desirable types of wildlife.

A growing consciousness of the importance of decreased forage production has given rise to a definite demand for remedial action. Urgent need is felt for management of the forage resource on a maximum sustained yield basis not only to contribute to the stability of the livestock industry but to prevent heavy soil losses, to regulate streamflow, to permit maximum wildlife production, i. e., to offer the fullest land use possible.

It is toward this goal--the satisfactory solution of range rehabilitation and maintenance problems--that a large part of the research of the Intermountain Forest and Range Experiment Station is aimed.

SPECIFIC RANGE PROBLEMS OF THE INTERMOUNTAIN REGION

Maintenance and rehabilitation of the forage resource constitute the two big problems in the management of the 145 million acres of Intermountain range lands. Of this vast area only 33 million acres now support a reasonably satisfactory plant growth, limited primarily by climate and natural physiographic factors; naturally, maintenance of the existing plant cover is the management objective on such lands. On the remaining 112 million acres, however, depletion has been so severe and encroachment of inferior plant species so general that reestablishment of a valuable plant cover is the first step toward restoration of forage productivity. Because of the extent of these depleted lands, rehabilitation demands primary emphasis now.

To secure rehabilitation or maintenance, the solution to many individual specific problems must be sought. Successful management of any specific range area may require accurate information concerning a few or all of the principles of normal range plant growth, plant growth and forage production as influenced by variations in climate, successional status of existing plant types, nondestructive plant utilization, season and method of grazing, methods of handling livestock, chemical composition of range forage and the use of supplemental feeds, methods of control or removal of inferior plant species, methods of artificial revegetation, methods of judging grazing capacity and many other allied subjects. These are specific problems within the region with which administrators of range lands are confronted.

But the successful solution of the problem of maintenance or rehabilitation is far from completed by the acquisition of such specific knowledge. The objectives of wild-land management--the fullest sustained land use--consistent with demands for timber and water production, wildlife, and recreation require close integration of the demands for forage with other requirements. Not only need specific principles relative to management of range lands be tempered by allied land uses, but such physical factors of the area as character of topography, type of soil, frequence of torrential summer storms, distance of range forage supply from water and many other features require consideration. For any range area then, by far the major range problem is proper range use--what use can be made of the forage consistent with other demands on the land and with the physical features peculiar to the area. Information from specific studies lend only to the solution of this major range use problem; they are not in themselves the answer.

For the livestock industry as a whole, range investigations may not only determine methods of managing native ranges to promote sustained forage yield but it may furnish valuable counsel to the individual livestock operators themselves concerning the most efficient type of enterprise to conduct and its relation to dry-farming, irrigation, rural life and community welfare.

Thus the problems of the region are to secure information essential to sustained forage production and information concerning efficient livestock enterprise, i.e., to establish an economically sound industry upon a stable resource

RANGE PROBLEMS NOW BEING STUDIED

With the Intermountain Forest and Range Experiment Station, the major organization conducting range research within the Intermountain region, is vested the responsibility of securing the basic information necessary for successful range management and in conjunction with administrators of range lands to aid in the solution of the general range use problems of the region. In other words, range problems of the Intermountain region are problems of the Intermountain Forest and Range Experiment Station.

Each vegetative type and each season of use within the region form a specific problem in maintenance and rehabilitation. Certain generalized principles may apply to all areas but each single vegetative type, owing to the plant species characterizing it, the type of soil upon which it is growing and the type of changes following slight or severe depletion is a specific problem in itself. As such, solution of the problem is dependent upon investigations upon that specific type. But obviously such a field of endeavor is much too large to encompass completely and permit the accurate and efficient solution of each problem. It is necessary, therefore, with the limited personnel of the Intermountain Forest and Range Experiment Station, to limit the field of endeavor to certain specific types and problems.

Three branch stations located in the three major vegetative types form the major work centers for range investigations in the Intermountain region. The Great Basin Branch Station, devoted to open forest summer range problems of the Wasatch Plateau is located in Ephraim Canyon in central Utah. The Desert Range Branch Station, for studying the problems arising on the salt-desert-shrub winter range type of western Utah, is located 50 miles west of Milford, Utah. Investigations of problems attendant with the use of sagebrush-grass spring-fall ranges are being attacked in cooperation with the Bureau of Animal Industry at the U. S. Sheep Experiment Station, Dubois, Idaho. At each of these three work centers the following problems are being studied with respect to the specific type in which the center is located:

1. The effect of viscissitudes of climate on plant growth and forage production and the adjustments in management necessary to compensate for such variations.

2. Successional status of existing vegetative types and with reference to their potential structure under proper management and the rapidity with which changes in structure may be brought about.

3. The best methods for preventing the encroachment of undesirable annual and perennial plant species and methods of eradication on areas where such species have become objectionable by their abundance.

4. The relative influence of different methods, intensities and seasons of grazing upon sustained forage and animal production.

5. Determination of the proper degree of utilization for important key forage species and the factors influencing it.

6. Utilization standards for judging the condition and degree of use on range lands.

7. Methods of judging grazing capacity of range lands and of conducting recurrent range inspections.

8. Efficient methods of studying native range vegetation, methods of sampling and types of experimental design that may increase the efficiency of range experimentation.

9. Artificial revegetation or reseeding of range lands is necessary to restore their productivity.

The last project with headquarters in Ogden, in addition to conducting studies at each of the three branch range stations is conducting studies at field trial centers near Boise, Idaho; near Wells and Paradise Valley, Nevada; near Bountiful, Utah; and near Kemmerer, Wyoming. One critically important phase dealing with plant breeding of forage grasses is being operated at Logan, Utah in cooperation with the Utah Agricultural Experiment Station and with the Bureau of Plant Industry.

These investigations that are being conducted cover but a skeleton of the problems attendant with proper management of ranges of the Intermountain region; but they are so placed and designed that in addition to solutions of the specific problems of the areas upon which they are located they may yield information of a general nature which may serve as a temporary basis for management of those types and problems which are not specifically studied.

CURRENT ACCOMPLISHMENTS IN RANGE INVESTIGATIONS

Several significant contributions from range investigations being conducted on summer range, sagebrush-grass spring-fall range, salt-desert-shrub winter range and from studies of artificial revegetation have been made during 1937. In addition to established projects the western range survey permitted the beginning of a comprehensive inventory of forage resources and range problems of the Intermountain region.

Western Range Survey. The western range survey, cooperative between state experiment stations and various Federal agencies, has completed a detailed forage inventory of the entire range area of Gem County, Idaho (378,372 acres) and Wasatch County, Utah (728,161 acres). For these two counties a detailed analysis of range conditions, and required adjustments appear in a written report supplemented by maps and charts.

In addition, maps of inventoried range have been prepared and a partial analyses of range conditions completed for two counties in Utah; three in Idaho, and of one each in Nevada (Elko) and Wyoming (Sublette). A map and tabulations of AAA inspection data have been prepared for five other counties.

For the region as a whole this constitutes a range forage inventory on 5,350,000 acres of range land, not a proportionately large part of 145 million acres, but still an important contribution, especially in view of its being largely private or national forest range of key importance.

Salt-Desert-Shrub Winter Ranges. The objective of investigations on salt-desert-shrub winter ranges is to develop methods of management which will insure the restoration and maintenance of forage productivity and promote the best use of winter range lands.

(a) Valuable native desert plants under management can in 4 years restore their vigor and almost completely replace Russian-thistle.

Following four year's management on the fenced winter range at the Desert Branch Station, ricegrass produced twelve times as much forage as on similar adjacent unmanaged range, black sage eighteen times as much, white sage three times as much, and hop-sage but slightly less than thirty times as much, whereas the annual Russian-thistle is a hundred times more abundant on the open unmanaged range. An inventory of a 3,000-acre block of the enclosed range showed that it produced 2.3 times as much usable forage as did an adjoining block of outside range similar in extent and nature except that it was unmanaged.

(b) Good management of desert range lands produces ample profit in increased livestock productivity.

A band of 2,500 sheep, grazed on the experimental area during the winter of 1936-37, the following spring produced 11-1/3 pounds of wool per head and an 85 percent lamb crop without any supplemental feed. A comparable band of 2,600 sheep grazed on similar but unmanaged range produced only 10 pounds of wool per head and an 80 percent lamb crop even after using $400 worth of supplemental feed. The value of good range is clearly demonstrated; in this case it netted one sheepman more than $1,200 additional income over that of his brother whose sheep were equally good. During the winter of

1937-38, the two bands of sheep have exchanged places, that is, the one which last year grazed on the unmanaged outside range is grazing the enclosed managed range, and vice versa, in order to check the results.

(c) Intensity of use is found to be inversely related to winter gains of ewes.

Experimental pastures grazed very heavily, closely, moderately, and lightly produced changes in average sheep weights of -3.45, -0.37, +3.76, and +5.97 pounds per ewe, respectively. On unmanaged range, outside the experimental areas ewes lost 4 to 6 pounds per head. The difference in condition of a band of ewes which gains 3 to 6 pounds per head in winter and one which loses 1 to 5 pounds per head is vital and affects the sheep losses and the care and nourishment ewes can give their lambs.

Sagebrush-grass Spring-Fall Range. Investigations on sagebrush-grass spring-fall ranges have as their primary objective the development of methods of range management that will permit the maintenance or improvement of the usable forage resource under the early and severe use that this range type receives. These studies include, in addition to studies of management systems, investigations of methods of removing sagebrush to hasten range restoration.

(a) Early heavy utilization if not repeated year after year is not detrimental.

Early spring grazing resulting in utilization of spring forages to within 1 inch of the ground does not seem to be injurious to the plants unless this early heavy use is repeated year after year. When the spring grazing season is divided into four equal (15-day) periods, only 12 to 35 percent of the total seasonal growth is available during the first 15 days. At the end of this early grazing period the grazed ranges looked stripped and overutilized, but after the animals are removed, growth continues and produces the remainder of the total volume of forage, that is, 65 to 88 percent of it. Under rotation the spring range is divided into four areas each used for 15 days, beginning when grasses are 2 inches in height, the one used first in a given year being used fourth, third, and second in the succeeding three years. Thus the heavy use accorded an area during the first period is repeated only once in four years. Avoidance of grazing a given area repeatedly at the same stage of plant growth seems to be the important factor in maintaining range forage production.

(b) Average daily green forage consumption by ewes suckling lambs during 1937 was 8.97 $\pm$ 0.855 pounds.

During the spring of 1937 there was considerable variation in the amount consumed from one part of the spring grazing period to another. Ewes used in the experiment had a mean weight of 120 pounds. Variation in forage requirement may be attributable to many factors. Change in digestibility of herbage, decrease in herbage moisture content, and decrease in percentage nutrient content of herbage with the advance of the growing season, increase in requirement of ewe with birth of lamb, and increase in requirement of lamb with added age and size - all these and perhaps other factors tend to introduce variation in forage requirement where the experiment is begun with pregnant ewes that lamb within pastures. It is interesting to note that Beruldsen and Morgan in Australia found the mean daily consumption for a 90-pound ewe to be 7.8 pounds of forage ranging from 3.5 to 22 pounds.

(c) Increases in forage yield of more than 100 percent were obtained through sagebrush removal by fire.

Four sections of rolling lava-plains sagebrush-grass range near St. Anthony, Idaho were burned in the summer of 1933; slight wind erosion during the fall following the fire was successfully halted by stabilization of soil the following spring. Herbaceous species were protected from grazing during the spring following the burn, and recuperated so well that by 1937 the forage production of the area had doubled. Liberation of soil moisture formerly used by sagebrush doubtless was a big factor in the remarkable recovery of the herbaceous cover.

(d) Sagebrush returns very slowly on areas properly burned and correctly managed following burning.

Not only has total forage production on the burned-over range been more than doubled in the 5-year period since burning, but sagebrush, totally annihilated by fire, has established very little reproduction on the burned areas. Moreover, since nearly all sagebrush plants found in 1937 on burned areas were 1937 seedlings, only four or five plants having come through from previous years to establish themselves, indications are that under proper grazing management competition by grass is too severe to permit sagebrush to reestablish itself. The mean numbers of sagebrush seedlings per 100-square-foot plot were 15.24 for unburned range in comparison with 2.73, 0.70, and 0.43 plants per plot for lightly, moderately, and heavily burned range respectively. Since the only seed source on burned areas is from adjacent unburned areas and usually distance from seed source varied directly with the increase in intensity of burn, the size of the original burn may be influential in determining the rapidity with which sagebrush returns to the area.

(e) Total cost of sagebrush removal by fire may exceed 15 to 20 cents per acre.

Cost records collected during 1937 indicate that organized controlled sagebrush removal by fire when performed in four section units may cost 10 cents per acre burned. This cost includes the construction of a double fire line necessary for the control of sagebrush fires. An additional expense of 5 to 10 cents per acre incurred by the loss of grazing privileges for one year or more may be charged against the cost of sagebrush removal. Thus the total cost of sagebrush removal by controlled fire may exceed 15 to 20 cents per acre.

(f) Forage inventories by the weight estimate method provide the desired yield data and are reasonably accurate.

For pastures and other experimental plots that require a recurrent forage inventory each year or at other intervals, the yield can be estimated with considerable accuracy directly in weight of herbage. This estimate of productivity when changed to pounds per acre, is easily comprehended by stockmen. The weight estimate method is similar to the point-observation-plot method in general plot location principles but differs in that productivity is recorded in grams weight instead of in square feet density and a systematic procedure of comparisons of estimates to actual yields is provided.1/ Weight estimates are much more accurate for the yield of the season in which they are taken, and are therefore highly desirable for recurrent measurements.

Open forest summer ranges. The objective of investigations on open forest summer range lands is to develop methods of management that will insure maintenance and rehabilitation of the forage resource on these lands.

(a) Food storage in plant roots is influenced by time and intensity of herbage removal.

Carbohydrate storage in the roots and stem bases of mountain brome, slender wheatgrass, and geranium is greatly lessened when the top growth is removed by clipping during the period of rapid height growth. Clipping only once early in the season permitted nearly normal storage by allowing, after clipping, nearly full time for herbage growth and for carbohydrate manufacture and storage. Early clipping followed by repeated clippings of young growth was highly exhaustive of storage supplies. When performed only once, clipping was progressively more exhaustive the later it came in the growing period, clipping even at seed maturity affording only very low storage. Complete removal of the top growth at this time prevents

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1/ (a) Pechanec, J. F. and Pickford, G. D. Weight estimate method for the determination of forage or pasture production. Jour. Amer. Soc. Agron. 29:894-904 (1937).
(b) Stewart, George and Hutchings, S. S. The point-observation-plot (square-foot density) method of vegetation survey. Jour. Amer. Soc. Agron. 28:714-722 (1936).

the normal movement of food from tops to roots that begins after seed maturity and continues for some time thereafter. Clipping during a period of rapid top growth is especially exhaustive as nearly all carbohydrates are then in the tops. Moderate removal of top growth leaving 4 inches height unharvested allowed good storage. Slender wheatgrass was less affected by clipping at almost any period of growth than was mountain brome.

(b) Climatic conditions within any one mountainous locality may be extremely variable.

Past weather records recently compiled show for the Great Basin Branch Station, that as the mountain is ascended in Ephraim Canyon, Utah, precipitation increases from 11.70 inches in the pinyon-juniper zone at 5,543 feet elevation and from 17.51 inches in the oakbrush zone at 7,655 feet to 29.48 inches in the aspen-fir zone at 8,850 feet. At 10,100 feet in the spruce-fir zone the precipitation is 28.01 inches, decreasing probably because the clouds pass over the crest instead of backing against the mountain. Of the total precipitation 54, 70, and 80 percent comes as snow in the pinyon-juniper, the aspen-fir, and the spruce-fir zones, respectively. In the same zones the length of the growing season is 120, 87, and 80 days, respectively. Precipitation and temperatures vary greatly from year to year.

(c) Yearly variations in forage yield from 120 percent above to 77 percent below average may occur in subsequent years.

(d) Germinative response of several range plants seems to be a species characteristic influenced by locality, year and other factors.

Germinative response to temperature, alternate moistening and drying, rate of drying, and other factors show these requirements to be largely individual plant species characteristics. Viability of seed is not only characteristic of the species but varies greatly both with locality in any one year, and from year to year for any one locality.

(e) Utilization standards are being prepared for Intermountain range lands.

A rough draft of tentative standards of utilization has been prepared from past records and experience, with the Intermountain Station and Region 4 cooperating. These tentative standards to be tested in the field by selected rangers, technical grazing men, and station men in range research, will be adjusted from year to year as data and experience warrant, and should eventually yield approximately correct standards for proper grazing utilization of the major vegetative types. Such a procedure, together with standardized procedure to be followed on inspection tours, may aid materially in determining forage utilization and range conditions.

Artificial Revegetation. The objective of artificial revegetation investigations is to determine methods of successful artificially rehabilitating range lands.

(a) Low cost methods of planting seeds are feasible on many range lands of considerable area.

On the Boise and Manti National Forests, for example, it has been found that even on slopes as steep as 40 percent or more, narrow seed drills can be used for strip seeding on approximate contour levels. Range lands not covered with large stones or coarse brush, and abandoned lands are best seeded with a disk-type grain drill, as this constitutes both the cheapest and most effective method of getting the seed evenly distributed and covered with soil. When seeded in strips with one-fourth to one-half the land actually drilled, the cost of labor need not exceed $1.00.

(b) Soil preparation may be deterimental to successful reseeding.

To drill grass seed without previous soil preparation, right amongst vegetative litter including rather vigorous stands of Russian-thistle, on abandoned cultivated lands or depleted range lands, has proved both cheaper and in many cases more effective in getting stands than if the litter be removed before the seeding is done. The partial shade of the dead herbaceous material not only aids in protecting the seedling grass plants from excessive temperature and evaporation until they have produced well-developed root systems and some top growth, but effectively lessens hazard of wind and water erosion. Tillage of the surface soil removes or crushes the dead material and allows the soil to dry quickly, thereby exposing grass seedlings to the direct action of sun and wind and causes over-rapid drying.

(c) Autumn appears to be the best time for reseeding grasses in the Intermountain region.

This is a principle that has been indicated by reseeding experiments up to the present. In addition to the experimental plantings of approximately 3,000 small plots, a watershed area of more than 200 acres was seeded on the Boise Forest in September 1937, and good seedling stands obtained. While it is not known how the various seeds will come through the winter, it is anticipated that establishment is the most difficult problem. Fall establishment of young plants gives them the entire spring period and spring moisture to develop root systems and to make vegetative growth.

An indication has been obtained that bulbous bluegrass (Poa bulbosa) and perhaps other grasses, in some cases at least, are able to compete successfully with downy chess (Bromus tectorum). It would be distinctly valuable to find a long-season perennial, or even a mid-season perennial, that would invade dense stands of cheatgrass and compete with it to advantage.

About 2,000 plots now seeded will shortly yield information as to the species most suitable for reseeding at different elevations, on soils in different stages of preservation, and on sites presenting different degrees of aridity. Two plant nurseries, one in the foothills and one in the lower valley near Ogden and on a drier site, are producing young plants that will permit detailed observations regarding survival and the yielding ability of 60 or more forage species. It has already been established in these nurseries that transplanting can be done cheaply and successfuly on porous soils as well as on the more favorable soils of the moister foothill lands.

NEEDED ENLARGEMENT IN RANGE RESEARCH PROGRAM

The present range investigative program needs some enlargement of existing studies and direct attack on some critical problems in order that it may better supply the information necessary for intelligent management of the Intermountain ranges. Programs at existing range stations should be amplified to include pasture controlled grazing studies at the Great Basin Branch Station, studies of the nutritive character of native range forages, studies of management on mountain meadows and stream bottoms, and the initiation of planned phases of artificial revegetation.

Despite the fact that the present program covers in a very broad way problems arising within the Intermountain region, certain vegetational types either through extreme depletion or through economic importance warrant extended study of specific phases. The following problem areas demand early attention:

1. Open forest summer ranges. Although this range type is generally conceded to be least seriously depleted, nevertheless, from the standpoint of productivity and the multiple use that such lands receive, it constitutes the most important problem area within the region. Rough topography, steep precipitous slopes, in many cases loose erosible soils, torrential summer storms make maintenance of forage cover highly imperative. Even though summer range problems are being attacked at one station within the region, far more attention must be given to the forage utilization and range management of this important range type. At the present time no direct attack is being made on the problems in Nevada, Idaho, and Wyoming. Suitable areas for experimental work may be found on the Santa Rosa Division of the Humboldt National Forest in Nevada, on the Sawtooth National Forest in Idaho, on the Targhee National Forest adjacent to and conducted in conjunction with the studies at the U. S. Sheep Experiment Station, Dubois, Idaho, and on national forest land in western Wyoming.

2. Abandoned dry farm lands: Areas of abandoned farm lands which have suffered from subsequent mismanagement and reverted to inferior plant species might, if a usable plant cover were restored, relieve to a considerable extent the stress on adjacent spring-fall and summer ranges. A satisfactory site for studies of rehabilitation

of such lands and their subsequent grazing management is being developed by the Farm Security Administration near Benmore in Tooele County, Utah and it appears likely that this area will be turned over to the Forest Service.

3. The extensive areas now occupied principally by downy chess: Portions of sagebrush-grass range that by injudicious burning and grazing have become clothed by a dense cover of downy chess (Bromus tectorum) are in many cases critical areas. Downy chess, a short season annual, neither provides sufficient protection to soil nor supplies much forage; furthermore, owing to its aggressiveness and tenacious nature it hinders successful natural and artificial revegetation. Ecological and grazing management studies are imperative to determine the possibility of replacing downy chess on extensive range areas.

Administrators of range lands, either public or private, cannot be criticized for malpractice and range misusage in the absence of definite information relative to sound management practices. It remains to range research to lead the way, to solve problems and to furnish counsel on matters pertaining to range management and restoration.

THE INTERMOUNTAIN WATERSHED LANDS AND THE STATUS OF INFLUENCE RESEARCH

THE "JEKYLL AND HYDE" ASPECTS OF MOUNTAIN WATERSHEDS

Ever since the turn of the 18th century, the 45 million acres of mountainous forest and range lands which make up the headwaters and foothills of the Great Basin, Upper Snake River and Upper Colorado River drainage systems have played an important part in the growth and economy of the Intermountain region. The usefulness of the mountains was first exploited by roving trappers in search of fur-bearing game. Settlers soon followed the trappers, and these folk, with aspirations of empire in their souls, were quick to see in the mountains the timber they needed for their homes, the forage required by their flocks, and useful minerals. Moreover, in the streams that came down from the uplands they saw the water that would make life possible in the semidesert valleys. Accordingly, they established their homes, farms, and industries in or near the mouths of the canyons at the base of the mountains where the soil was most fertile and where the essential resources of water, wood, forage, and minerals of the adjacent watershed lands were most accessible. Others have followed the early pioneers and today nearly a million people with several billions of dollars invested in social, agricultural, and industrial activities and facilities, live in the shadow of the mountains of this inland empire.

The strategic location of the intensive valley developments with respect to the mountains has proved to be, however, not without serious limitations. For in recent years, by reason of the physiographic and climatic characteristics of the watershed lands together with the ease with which their watershed function may be impaired by unwise resource use, serious water shortages, accelerated erosion, and destructive floods have occurred, to the detriment of all phases of life in this region. Thus, while the people have long since appreciated the value of the mountains as a reservoir of essential resources, they are now beginning to realize that the run-off and erosion potential of these lands constitutes a hazard which must be more fully understood if the security of their investments is to be assured.

THE HAZARDS OF MOUNTAIN WATERSHEDS

To understand the vulnerability of the valley communities to water shortages, erosion, and floods it is essential for one to look beyond the irrigation flood gates in the fertile fields and the reservoirs and diversion works in the canyon bottoms to the mountain slopes where precipitation is first intercepted and started on its way to the dependent areas in the low lands. On these mountains one finds critically assembled all of the factors which are conducive, not only to naturally limited supplies of usable water, but also to exceptionally rapid run-off and erosion processes.

The mountains of this region for the most part are characterized by steep slopes, high gradient channels, generally shallow and easily disturbed soil, and a forest and range cover that rather completely shelters the ground on areas at the higher elevations, but which at the lower elevations and especially on south and west slopes, leaves considerable portions of the surface soil exposed to the direct impact of the weather. The total amount of precipitation on these lands varies widely from year to year. Most of it falls and accumulates as snow during the winter to be released, frequently with great rapidity, by warm temperatures in the spring. Lesser quantities of precipitation occur during the summer months, commonly in the form of torrential storms of short duration but extremely high intensity.

One of the net results of these physiographic and climatic relationships is a highly variable annual discharge of water from the watersheds. Another and more far-reaching result is that the annual streamflow regimen is characterized by high stages of flow during the spring and early summer following the melting of snow when water is not greatly needed in the valleys, and low stages during the late summer and fall when water is most urgently needed to supplement soil moisture deficiencies on irrigated tracts and to produce power for the operation of industrial plants.

The normal factors which tend to create limited and uncertain water supplies are not the only limitations of the mountains. For while a considerable portion of the spring run-off has been conserved or made available by reservoirs, transmountain diversions, and wells, further developments of this kind are decidedly limited owing to a dearth of feasible sites. Moreover, because of normally rapid gradational processes on the mountains, the downstream structures already installed are in constant danger of destruction or impairment by floods and siltation from the tributary slopes above them.

Over and above the normal hazards presented in the mountains is the added danger of unwise resource use by man. In digging minerals, in harvesting timber and forage, and in developing recreational opportunities, man, directly or indirectly, has caused serious depletion of the plant cover and soil disturbance. As a consequence of impairing the normally restraining influence of the plant and soil mantle, accelerated erosion, abnormally rapid run-off and even destructive mud-rock flows are now common on many watersheds in the region. These abnormal occurrences, by causing floods of unusable water, the silting of reservoirs and the damaging of other downstream improvements, have greatly accentuated the seriousness of a naturally scant water supply and have emphasized the need for the rehabilitation and conservation of the watershed function of the mountainous lands.

THE FUNCTIONAL ASPECTS OF WATERSHED MANAGEMENT

Because of the variability of the physical and climatological characteristics of the mountains and differences in the degree of use and dependency upon the resources of these lands, the character and intensity of the watershed hazards differ widely from one part of the region to another. The problems presented by these hazards, however, fall into four distinct, though closely related, functional categories. These are:

1. Watershed Factor Problems, or those which require an understanding of the watershed management practices that are necessary for coping with the normal run-off and erosion potential of a given area, as well as with the specific difficulties presented by the operation of individual factors of climate, topography, soil, plant cover, and streamflow regimen.

2. Watershed Utilization Problems, or those which require the determination of the extent to which the watershed resources can be utilized for grazing, logging, mining, and recreational purposes without adversely affecting the yield of usable stream flow or the stability of the soil.

3. Watershed Control Problems, or those involving the development of measures for preventing erosion, minimizing floods, and improving the yield of usable stream flow on areas where these conditions are known to be unsatisfactory.

4. Watershed Survey Problems, or those requiring an accurate analysis of the character, extent, and cause of unsatisfactory watershed conditions and the formulation of recommendations for control measures in keeping with the benefits to be derived therefrom.

THE INFLUENCE RESEARCH PROGRAM

Influence investigations aimed at finding solutions for these functional aspects of watershed management are one of the major research efforts of the Intermountain Forest and Range Experiment Station. Research in this field is based upon the general hypothesis that the normal plant and soil mantle of a given area is conducive to optimum absorption of precipitation and infiltration of surface water into the soil and rock mantle, and to minimum surface run-off and erosion; moreover, that such relationships retain the soil in place and in maximum fertility, and contribute to delayed yields of silt-free stream flow to natural drainage channels.

Intensive studies of watershed management problems thus far have been confined to the Great Basin in Utah and the Boise River watershed in Idaho, although preliminary investigations have also been made in the Upper Snake River and the Colorado River drainage basins. The problems of these areas, the facilities now available for their study and current results obtained therefrom are outlined in the following paragraphs:

Great Basin - Utah

A naturally limited water supply and the absolute need for water to sustain all phases of life is one of the most acute problems in the Great Basin Province. Equally serious, however, are devastating mud-rock flows and serious losses of soil due to accelerated erosion and abnormally rapid run-off on the mountain slopes from which the water supplies, the forest and range resources, and recreational opportunities for this region are derived. These occurrences not only are causing loss of life, damage to property, and reduced productivity of the mountain soils, but also are rendering ineffective the downstream developments which make possible the storage, diversion, and distribution of stream flow.

The watershed problems center in part on restricted sore spots at the headwaters of the steep tributaries and in part also on extensive areas of both upland and foothill depleted range lands. The criticality of the headwater lands was recognized in 1912 at which time studies of the influence of range cover on run-off and erosion were initiated at the Great Basin Branch Station near Ephraim, Utah. The now famous A-B watershed experiment at the Great Basin Station has been continued to date, and in recent years this study has been augmented by more intensive studies at the Wasatch Branch Experiment Station near Farmington, Utah. Facilities at these two stations are now available for intensive studies of watershed factor, watershed utilization, and watershed control problems, and significant progress is being made in all of these fields.

Watershed Factor Studies constitute one of the most important functional projects in the influence research program for this area. These studies, as briefly outlined below, have been designed to furnish information concerning the specific influence of the climate and weather, the topography, soil, plant cover and stream flow characteristics upon the watershed function of the steep, mixed brush- and forest-covered mountains of the Wasatch Front, as a basis for planning sound watershed management and control measures.

a. Deep winter snows and high intensity summer storms have been recorded on the Davis County, Utah watershed in the past two years.

Snow courses have revealed that 25 to 42 inches of water accumulates in the form of snow up to April 1 on areas above 8,000 feet elevation, while a battery of 86 standard raingages and 2 intensity gages show that as much as 0.95 inch of precipitation in 15 minutes falls on these areas during summer storms. Moreover, no more than one inch of rain falling within 30 minutes has been sufficient to cause spectacular mud-rock flows from partially depleted watersheds of less than 100 acres in size. A continuation of records on these areas is needed as a basis for determining the periodicity of flood producing storms and the annual fluctuation of total precipitation.

b. South aspect watersheds along the Wasatch Front in Utah appear to yield more usable stream flow than north facing tributaries.

During the past year daily stream flow records were obtained from the North Fork (south aspect) and South Fork (north aspect) of Centerville Creek near Farmington, Utah. The South Fork of this stream discharged 98 percent of its total flow by the end of June, during which time 4.9, 74.4, and 17.8 percent was discharged in April, May, and June respectively. In July only 0.5 percent of the total flow occurred and this was followed by a 0.3 percent flow in each of the remaining months of the year. The North fork, on the other hand, discharged only 84.1 percent of its annual flow during April, May, and June, and during the remaining months in the year the relative monthly discharge was from 5 to 7 times greater than from the South Fork. Both streams reached highest stage in May, the North Fork discharging 45.4 percent in that month as compared to 74.4 from the South Fork. The more uniform and sustained flow of the stream from the south facing aspect appears to be due to recurrent melting of snow during the winter and a longer period of infiltration.

c. Micro-climate and soil formation being studied in Ogden Canyon, Utah.

On north and south aspects in Ogden Canyon paired installations equipped with soil and air thermographs, rain gages, and runoff plots to measure the micro-climate and soil formation processes have been in operation for a year. Analysis of the cumulated data is now going forward.

d. A satisfactory ocular method of estimating accelerated erosion has been developed in connection with soil loss studies in the mountain brush zone along the Wasatch Front.

This method involves a simple comparison of surface soil features between areas which are obviously eroding and those on contiguous areas which are not eroding. Laboratory analyses of soil samples from areas classified in the field as coming from uneroded, moderately eroded, and severely eroded sites showed high significant differences with respect to organic matter, total nitrogen, and moisture

equivalent, respectively, in the surface 6 inches of soil. The principles and technique developed in this study are being adopted throughout the region as a means of recognizing potentially serious erosion situations.

e. Plant cover influences run-off and erosion.

Further evidence of the beneficial influence of plant cover in controlling run-off and erosion is revealed in the records of the A-B watersheds at the Great Basin Branch and 16 run-off plots at the Wasatch Branch Station. As a result of changing the plant cover on Area B from 40 to 32 percent density while that on A was held at 40 percent, A-B ratios of run-off and soil erosion changed from 2.27 to 1.12 and from 2.50 to 1.12, respectively. These plant density changes represent the first stages of a reversal of treatment on these areas and indications are that further reductions in the plant cover on Area B to a proposed 16-percent density will yield irrefutable evidence with respect to plant cover influences. The run-off plot tests show that an open aspen stand with heavy litter and with a herbaceous undercover of 14.5 percent density was 75 times more effective for controlling surface run-off than a 4 percent cover of annual weeds and 52 times more effective than an 8 percent browse cover. Heavy soil losses occurred on the weed and brush range while none occurred in the aspen.

f. The short, steep watersheds along the Wasatch Front yield extremely low quantities of usable stream flow during the late summer months.

Records of stream flow are now being obtained from seventeen gaging stations in operation on experimental areas at the Wasatch Branch Station, and one of the streams, for which a full year of daily records is available, yielded about 71 percent of the total yearly flow during April, May, and June and only about 9.5 percent during July, August, and September, when the demand for water is most acute. A continuation of these records is needed to determine the variations in stream flow which may be expected from year to year on these watersheds.

Watershed Utilization Studies constitute a second important functional project in the Great Basin program. Aimed at determining the extent to which grazing may be permitted without injury to the watershed function, the studies in this field are concentrated on six mixed brush- and forest-covered tributaries of about 125 acres each in Farmington Canyon, and on triplicate 1/10-acre run-off plots in the oak-sage and aspen-fir zones in Ephraim Canyon. Run-off measuring devices and climatological instrumentation have only recently been installed on the experimental watersheds. It is planned to calibrate run-off and erosion on these areas during the next three to five years after which systems of nonuse, moderate grazing, and excessive grazing will be initiated on randomized duplicate watersheds.

Watershed Control Studies make up the third aspect of watershed management investigations in the Great Basin and these include not only the development of flood and erosion control methods, but also a study of water conservation. Primary interest has centered around the development, application, and results of contour-trenching for both flood and erosion control purposes, and upon the possibilities of conserving winter and spring run-off by spreading water for underground storage in the loose sands and gravels of the fans and deltas at the mouths of canyons.

a. Contour-trenches prevent floods.

Contour-trenches designed to hold 75 percent of a 2-inch storm have proved to be entirely satisfactory for preventing floods on the Davis County, Utah watershed during the past three years. In this period high intensity summer storms have not caused floods from controlled areas, whereas, adjacent uncontrolled watersheds which received approximately similar rainfall produced mud-rock flows. Practically all of the debris basins constructed during the past four years at the mouth of numerous watersheds along the Wasatch Front in Utah -- with the notable exception of those in Davis County -- are now filled with debris from floods in 1936 and 1937, and present a serious menace from overtopping in the next flood. Such a phenomena occurred in Willard in 1936 and contour-trenching is now being applied to the headwaters of that area in an effort to avoid the recurrence of further floods. These examples point to the futility of controlling floods in this region by down-stream structures alone, and to the efficiency of attacking these problems on the headwater lands.

b. A small, cheaply constructed contour-trench has been found suitable for erosion control purposes on low foothill lands where heavy snow accumulation is not a problem.

Using portable rainfall apparatus for testing purposes, it was found that unfinished "substandard" contour-trenches spaced at 12½ feet on 30 percent slopes and constructed at about one-third the cost of "standard trenches" yielded no run-off during storms of intensities equivalent to 3.6 inches per hour. These cheaper trenches are now being used on foothill lands near Salt Lake City. Further tests of this kind are planned as a basis for developing economically feasible contour-trenches for other soil types.

c. Contour-trenches materially increase the moisture content of the surface soil during the summer growing season.

A preliminary analysis of weekly records obtained last year on trenched and untrenched areas revealed the soil moisture content of the 0-6 inch horizon on an untreated south aspect site to be 13 percent on July 15, 4.5 percent on August 15 and 6.5 percent on August 30, while on comparable treated sites it was 19.5, 6.0, and 9.5 percent, respectively, showing a moisture content increase,

largely attributable to treatment, ranging from 35 to 50 percent. Soil samples taken in the trench bottom, on both sides of the dike and midway between the trenches, showed rather uniform distribution of moisture except immediately after a rain, indicating that the trenches serve as irrigation furrows for moistening the entire controlled area. Studies involving response of tree seeding survival to contour trenching are also under way.

d. A water-spreading experiment now under way in Davis County, Utah.

To determine the possibility of increasing underground water supplies through the use of winter and spring run-off, a water-spreading experiment was initiated at the mouth of Centerville Canyon last year. This study is cooperative with the Bureau of Agricultural Engineering, the Utah State Experiment Station, and the local water users. Water from Centerville Creek is being diverted into a flood control trench along the foothills above Centerville where it sinks into the coarse sands and gravels. Well records, both inside and outside the drainage basin, are being maintained to measure the effectiveness of this system. This effort has created much interest in Utah since water spreading, if it proves effective, appears to be the only major engineering development which offers promise of conserving large quantities of water on a great many of the minor tributaries of this region where, for the most part, surface reservoirs are not feasible. Bureau of Agricultural Engineering representatives have suggested further trials of this kind elsewhere in Utah and desire the cooperation of the Forest Service in this connection.

Bunchgrass Granitic Soils - Idaho

The water supply, erosion and flood situation on the Boise River watershed in southern Idaho is representative of many problem areas in the Upper Snake River drainage system. Here, prosperous valley communities developed almost wholly upon the basis of irrigation agriculture on 340,000 acres of irrigation lands and upon supplies of water, forage, timber, and gold from the 1,700,000-acre Boise River watershed, are now suffering from crop failures, flood damage, and decreased range productivity.

Notwithstanding the availability of about 400,000 acre-feet of storage facilities, total discharge of Boise River in years of drought has proved to be inadequate for supplying the farm lands with full shares of water. Moreover, excessive silt loads are being carried into the reservoirs and canal systems from placer diggings and from accelerated erosion on localized burns in the headwaters and on extensive areas of depleted foothill range lands. Furthermore, stream flow regulation and excessive sedimentation has raised the level of the main channel of the river above that of adjoining lands in Boise Valley and in recent years high water has overtopped the banks and caused serious property and crop damage.

The ground work for influence investigations on this area was laid in 1931 after a range-erosion survey revealed serious erosion and run-off to be occurring on the range portion of the watershed. Since then, facilities for intensive studies of watershed factors, watershed utilization, and watershed control have been developed at the Boise Basin Branch near Idaho City and at the Arrowrock Substation.

Watershed Factor Studies have, from the initiation of intensive research, been an important part of the program on this area. Under this project, progress has been made in studies pertaining to each of such specific factors as the climate, topography, soil and plant cover.

a. New type snow gage developed and tested at Boise Basin Branch.

A combination snowboard-raingage, newly developed and tested at the Boise Basin Branch Station last year, shows promise of yielding more accurate measurements of winter precipitation on areas which are subject to alternate melting and drifting of snow than the standard equipment heretofore used for this purpose. In a 6½-inch snow storm a battery of nine of these gages recorded approximately 50 percent more precipitation than was obtained by snow survey equipment. While this type of gage has proved to be satisfactory on areas where a daily attendant is available, there continues to be a need for a cumulating or self-recording instrument that will operate without attention for long periods of time. In this connection, buried rain cans and trough gages are being tested to determine whether such instruments will be affected by drifting and lateral movement of water.

b. Erosion increases with steepness of slope on the Boise River watershed.

The importance of directing erosion control efforts toward the steeper slopes of the Boise River watershed was brought out last summer in run-off and erosion measurements on 20, 30, 40, 50, and 60 percent slopes of depleted range lands. These tests revealed no significant influences of slope on run-off, but on the other hand, erosion was six times greater on the 60 than the 20 percent slope areas.

c. Intensive trampling and depletion of the organic matter content of the surface soil on the Boise River watershed must be avoided if the normal infiltration capacity of soil is to be maintained.

This conclusion is borne out by results of measurements made with portable apparatus which showed infiltration to be three times greater on areas that had been protected from trampling for four years than on adjacent areas where the soil has been subject to trampling and erosion. Similar measurements on other areas showed that the presence of organic matter in the surface soil is four times more effective than soil texture and five times more effective than soil moisture content in inducing percolation of surface water.

d. The lysimeter installation at Boise Basin Branch is now ready for water loss study.

Having previously determined that the perennial bunchgrass vegetation is much more effective for controlling surface run-off and erosion than annual plants commonly found on depleted range, efforts are now being directed toward ascertaining by means of lysimeter studies the relative water losses caused by these plants. Run-off, seepage flow, and retention (and evaporation) from 4-foot profiles of homogeneous, bare soil in six 2-milacre steel tanks has been recorded since 1934 as the first step in this study. The second phase of the study was initiated last season when two of the tanks were transplanted to bunchgrasses and two to annual weeds, two tanks being maintained in bare condition for control.

Watershed Utilization Studies constitute a second phase of research on this area and, as is the case of comparable studies in Utah, the major objective is to develop proper range-watershed management practices. Efforts in this connection are concentrated at two work centers. At the Boise Basin Branch Station near Idaho City two 10-acre grass- and brush-covered watersheds have been fenced and equipped with surface and seepage run-off, and silt measuring devices. The areas have been in operation for three years with no grazing use. It is planned to continue nonuse of these areas for another two years for calibration purposes and then initiate a system of grazing use comparable to that which has been used on the A-B watersheds at the Great Basin in Utah.

At the Arrowrock Substation near Boise, three 200-acre depleted range watersheds have been equipped with flumes for measuring run-off. Debris basins for the collection and measurement of silt are needed to complete this installation.

Watershed Control Studies make up the third and probably one of the most urgently needed phases of work on this area. Chief interest in this connection has centered upon ways and means of preventing erosion of the coarse granitic soils on depleted range lands. On the basis of past work, which showed conclusively that the present annual type of vegetation is inferior to the original bunchgrass cover for controlling erosion, current studies are being aimed at determining how to restore an effective plant cover. Noteworthy progress has been made on several aspects of this problem.

a. Promising erosion control methods being tested at new demonstration area.

In cooperation with the Boise National Forest an erosion control demonstration area has been established at the Arrowrock Substation where several promising methods of control measures are being tested. The upper half of a 300-acre tributary of Wood Creek is being used for this purpose and the methods being tested include (a) contour furrowing and shrub planting, (b) contour drill seeding to grass, (c) broadcast seeding of grass, (d) shrub planting in gullies, and (e) protection from grazing. It is expected that this area will yield sufficient information during the 1938 season for the planning of a much needed large scale erosion control program on the foothill range lands of southern Idaho.

b. Progress made on erosion control methods.

Several advances in erosion control technique have been made during the past year. It has been found possible, for example, to drill seed in contour strips with a modified 1-horse drill on slopes as steep as 70 percent. Drilling has been found to be much more effective in establishing artificial grass stands than broadcast sowing. Moreover, drilling by machine on contour strips can be done at about one-fourth the cost of broadcast sowing on a complete coverage basis. Tests with portable rainfall apparatus have also shown that a cheaply constructed contour-trench will prevent run-off on barren areas even under the most severe rainfall conditions expected in that area. Further tests of the effectiveness of contour seeding and trenching for controlling run-off and erosion are planned for the coming year.

FLOOD CONTROL SURVEYS

In accordance with the Flood Control Act of June 1936, this station, in cooperation with the Soil Conservation Service and the Bureau of Agricultural Economics, has been authorized to make a preliminary examination and report upon run-off and waterflow retardation and soil erosion prevention on the watersheds of the Green River and its tributaries in Wyoming and the Snake River and its tributaries in Wyoming. Authorization for the latter study has been amended so as to cover tributaries in Idaho, Oregon, and Washington. Field and office compilation on both the Green and Snake River surveys in Wyoming has been completed and reports thereon are now being prepared. Agreements have been reached with cooperating agencies concerning the division of responsibility of proceeding with the examination of the remainder of the Snake River with a view toward completing this report during 1938.

SUMMARY

After a period of exploratory research which began in 1912, and which has contributed not only timely aid in the control of serious flood and erosion problems but also important concepts for a long time program of watershed conservation, the Intermountain Station is now equipped with a program and facilities for conducting further, and much needed, intensive influence research upon the watershed problems of the Great Basin and the bunchgrass-granitic soil range lands of southern Idaho. Based on preliminary studies a program of investigations has also been prepared for intensive study of the erosion and silt problem in the Colorado River drainage, for influence investigations in the ponderosa pine forests of southern Idaho, and for an extension of flood control surveys in the Colorado River drainage, and in the Great Basin. The major obstacle to the effective prosecution of the program on these areas is, as has been in the past, a lack of funds for adequately manning and operating the available facilities. Notwithstanding fairly liberal allowances of emergency funds, which have made possible the development of the present program, the financial status of the Influence projects is critical and needs immediate consideration.

R - INT
Investigative Program
and Report

THE FORESTS OF THE INTERMOUNTAIN REGION: PAST USE, PRESENT STATUS, AND PROBLEMS OF PERMANENT FUTURE USE

Of the numerous tasks confronting the pioneer in the timbered portions of this continent, particularly beyond the Mississippi, perhaps none was more arduous than the taming of the forest frontiers. For though timber for shelter and fuel for fire were prime necessities -- these were all around him in quantities that appeared to have no bounds. He needed food first and foremost, but the woods and waters, literally teeming with wildlife, could not supply all his wants. Strangely enough, in the midst of all this prodigality only the soil could provide those staples giving guarantee of a reasonable level of existence, and to get at the soil he destroyed the forest. Occasioned primarily by the need for tillable acres, forest destruction at first proceeded on a rather picayunish scale. But in a lusty, growing nation life could not long remain on a subsistence basis. Soon there was need for not only food but also vast quantities of lumber to expand and to build cities and villages, and to provide permanent homes for the sod-shantied pioneers on the prairies. In fact the breaking of the virgin sod of the Great Plains region created a demand for lumber, the like of which history, doubtless, never again will record. In that period the full play of economic, social, and political forces encouraged ruthless exploitation, resulting in large-scale forest devastation which now cannot be rectified merely through recrimination or regret. Now we are privileged only to ruminate with all the sadness of conviction that an agricultural empire was being erected while the forest dominions of the nation were whittled down by the logger's axe and the plow of the pioneer.

In the Intermountain region circumstances conditioning use of timberlands were somewhat different, resulting in a patter of exploitation, less vicious in character, though none the less thorough. Here the pioneers (without notable exceptions) settled not in the forested areas but rather along river plains or in valleys at debouchures of mountain streams where the snow melted early and water was easy to divert. Nevertheless, here as elsewhere the needs were acute for "fires against the cold, and roofs against the rain"; but here the raw materials were not always available in one's "back yard." Quite the contrary, it was often necessary to haul wood supplies from long distances, down rough ravines and treacherous trails. One might have assumed, therefore, that where no need existed for destroying trees to make room for the plow, the timber resources would have been saved from drastic pillage. But not so. The needs of rapidly increasing numbers of miners,

valley settlers, and others for wood soon exceeded the readily accessible supply, and it was not very long afterwards that even in stands relatively remote from centers of population, timber harvesting assumed an exploitative trend with consequent destruction of forest productivity.

EXTENT OF FOREST AREA, VOLUME, AND USE

Since the early days of settlement by white man, forest and woodland areas in the Intermountain region have not dwindled materially in extent, but fire, over-cutting, and natural enemies of trees have reduced the productivity of the timber resources on existing tracts in many instances far below site potentialities. While accurate figures on area and volume are not yet obtainable, various estimates place timber and woodland acreage for the entire region at somewhat more than 25 million acres, 12 million of which are in southern Idaho, over 5½ million in Nevada, nearly 5½ million in Utah, and almost 2½ million in western Wyoming. These acres support a commercial stand of saw timber (12 inches and over in diameter) of nearly 50 billion board feet in volume, a young stand (4 to 12 inches in diameter) of about 17 billion board feet, and a fuel wood stand (principally aspen, mountain mahogany and pinyon-juniper) well over 50 million cords.

Consumption of lumber in past years has been comparatively heavy. Ten years ago the regional average was nearly 480 board feet per capita, and in peak years it has doubtless exceeded 500 feet. In the future, under hoped for stable conditions, in the absence of artificial stimuli, and with a proportionate use of substitutes, per capita consumption will probably never again exceed this figure, nor is per annum consumption of lumber in the region expected to exceed 500 million board feet for a long time to come.

Today the timber cut for the region is in the neighborhood of 160 million board feet. Of the four states wholly or partly in Region 4, southern Idaho alone has a timber cut roughly equalling the amount it consumes. Practically all of the domestic lumber consumed in Nevada is derived from outside states, likewise over 90 percent of Utah's and a material portion of Wyoming's. Yet in 1870 Nevada's forest resources yielded a cut of 35 million feet; Utah's cut of timber equalled 26 million feet in 1880, Wyoming's over 30 million in 1910. (These are representative decennial figures and are not necessarily indicative of peak year production.) Today Nevada's cut is confined almost entirely to fence materials, fuel, and the like; Utah's cut has decreased until by 1936 it was only 12 million feet; and rough figures for southern Idaho and western Wyoming indicate that there too production is on the wane.

WHY INTERMOUNTAIN FORESTS MUST BE KEPT PRODUCTIVE

There are several good reasons why the forest areas of the region should be restored and maintained in a productive condition; a few will be cited here. In the past the forests of the region have supported some 370 sawmills, a surprisingly large number for a comparatively small original timber volume. Over 80 of them are idle today principally because merchantable timber is no longer available in sufficient quantities to warrant operation. The majority of the mills are small, remote from railroads, often operated merely as supplementary enterprises, and manufacturing lumber for local consumption only; consequently, their products do not come in competition with the general market. Nevertheless, in numerous localities throughout the region the sustained activity of this industry is vital to the maintenance of tolerably high standards of living. Dearth of raw materials results in ultimate shut-down of mills with direct financial losses to the operators and employees, and with indirect but none the less real losses to the community as a whole.

In addition to the need of a continuous supply of saw timber to maintain these mills in operation, there is a constant demand for other products such as posts, poles, fuel and the like. The existing forest areas are for the most part so situated that they are accessible to many rural communities as well as to individual farms and ranches. The farmers and ranchers who have ready access to timbered areas supplying fuel, fence posts, poles, and the like may be considered fortunate indeed. National forests, in providing free use of timber to bona fide residents, perform a real service in this regard, especially where dire needs of indigent individuals are being fulfilled.

It is fairly obvious, without further illustration, that there is a real need for managing the timber resources in such a manner that full productivity shall be realized, guaranteeing continuous supplies of wood to all peoples of this region. But to argue restoration of this resource in the Intermountain country solely on the basis of permanent timber production is to adopt a view that is narrow and hardly tenable. The forests have other uses which must be given careful consideration in multiple use plans for timbered wild lands. In most cases prudent harvesting of timber products will permit simultaneous use of the same areas for other purposes, but cases may arise where other uses will surpass timber production in value and conflict with its use.

Among the other uses watershed protection is generally of first importance, though the degree of protection necessary is dependent on the character of the individual watersheds. Forests in general, and timber stands in particular, constitute one of the most effective guardians of nature's great reservoir, <u>the soil</u>. When one considers that nearly a million people living in the semi-desert valleys of the Intermountain region are dependent upon the

water that is stored on the lands at high elevations, and that a major portion of these lands are now within the boundaries of national forests (though not necessarily in national forest ownership) one begins to gain some appreciation of the tremendous influence that timber stands exert on public welfare quite apart from any regard for wood use.

Grazing is another use that is intimately and inseparably linked with forest use. More than five million sheep and one million cattle depend on the ranges of the Intermountain region for their entire feed supply from six to twelve months of the year. Large numbers of these find their summer forage in the forests and woodlands that cover the watersheds, the vegetation associated with the timber species constituting an important and integral part of the wild land resource.

Recreation is another use which is steadily rising in importance and which is now being given more and more recognition in the integrated use plans for national forests. Obviously, the timbered areas must count large in the present and future welfare of recreational programs. For while winter sports enthusiasts may seek the snow of open hillsides, the summer recreationist for real enjoyment turns away from the heat and dust of the deserts and foothills to seek escape to the tree-hemmed lakes and the shaded streams of the wilderness -- the green enchanted coolness of the forests. The hundreds of thousands of visitors that flock yearly into the national forests of the Intermountain region do so because they love the free seclusion still afforded by those areas where the timber grows tall and the creeks run cold and clear.

Wildlife and forest (animal and plant) ecological relationships represent still another natural association that cannot bear ruthless or arbitrary severance. The life and propagation of many important game species are dependent on forests and woodland cover. Protection in forests is, therefore, vital to the wildlife resource.

PROBLEMS IN MAINTENANCE AND RESTORATION OF FOREST PRODUCTIVITY

In the preceding paragraphs the importance of the timber resource in itself has been emphasized and the interrelationship of water, wildlife, forage, and recreation briefly mentioned. The thought has been to convey the idea that forests are complex communities; that if they are subjected to drastic treatment not the timber growth alone but all associated values are affected; and that the people of the Intermountain region should awaken to the fact that in their timbered acres "they've got something" that is really worth keeping. But the value that can be derived from these acres is dependent on the degree to which their productivity can be restored, and how well that productivity can be maintained. This is far from being a facile task, for the choicest areas of timber in the region have been allowed to deteriorate through short-sighted methods of harvest followed by fire and insects, reducing the growing stock and lowering the increment on many areas to the

point where only intensive forestry measures can restore the land to acceptable levels of productivity. The minimum requirements designed to accomplish the ends of good forest management appear to be: (a) adequate protection of all forest areas; (b) silvicultural measures, particularly methods of harvest cuttings and stand improvement, that will insure regeneration of desirable species and improve the quality and growth of residual stands; and (c) artificial regeneration of the forest cover on areas where timber has been destroyed by fire, overcutting, and other abuses.

The problems of forest protection are regionwide, and involve both fire and insects. The fire problems are particularly acute. Over 29 million acres in the region are in need of intensive protection. Man-caused fires are still all too prevalent and there is still some lack both of public appreciation of the magnitude of the fire problem in its entirety and of whole-hearted public support for the fire control program. Damage in bad years is intolerably heavy. Central and western Idaho, owing to peculiarities of fuel and climate, comprise the more acute problem areas in the region from the standpoint of fire danger and control, but during bad seasons, danger may reach high levels in eastern Idaho, western Wyoming, and Utah as well.

Insect damage results in high volume tolls of merchantable timber every year. Losses are particularly heavy in the lodgepole pine, white bark pine, and white fir types, but appreciable losses do occur also in Engelmann spruce and ponderosa pine, and to a lesser extent in Douglas fir. In the extensive ponderosa pine stands of central Idaho, infestation is apparently in an endemic state so it is thought that proper silvicultural measures during intermediate and harvest cuttings will continue to keep losses within a reasonable figure. In types where the stakes are high and infestations threaten to reach epidemic proportions, special measures of control are necessary.

Silvicultural problems are also important despite the fact that the major portion of the choicest timber tracts in private holdings has been already cut-over. However, on national forests only a relatively small acreage has been cut-over while in federal ownership, certain portions having been harvested once or twice before withdrawal. Very material portions of the land in national forests embrace rough, inaccessible country in which natural cover balance is so precarious and timber so poor that it never can be regarded as potential timberland but must remain perpetually in watershed protection use. For this reason it is apparent that in order to augment the shrinking timber supply, forestry measures must be intensified not only on lands now in public ownership but on all timberlands in the region. There seems little reason to doubt that the combined areas now accessible and capable of growing merchantable species if restored and maintained at resource productivity could well supply the major portion of the region's need for timber. At present the most pressing silvicultural problems are in the ponderosa pine type of central Idaho and in the lodgepole pine types of western

Wyoming, Utah, and eastern Idaho where the largest commercial operations and the more important national forest timber sales are now in progress. In both types the problem of securing adequate stocking through natural regeneration and of increasing increment and reducing mortality in residual stands is particularly difficult. This same problem is also of considerable importance in Douglas fir, and Engelmann spruce types, especially in Utah, where small mill activity is making heavy inroads into relatively meager existing supplies.

If maximum growth and quality are desired, stand improvement measures in the form of thinnings appear necessary, not only in the dense, stagnant pole stands of lodgepole pine, but also in stands up to 60 years of age in ponderosa pine as well as other types, particularly if there is a market for the products of the cuttings.

Pruning of second-growth ponderosa pine is imperative if clear lumber is desired in rotations as short as 150 years.

In the field of artificial regeneration, problems center on restocking of areas like the Quartzburg burn of 1931 which used to be one of the choice ponderosa pine sites in the region, and of such denuded watersheds as the Wheeler Basin, and Willard and South Fork Canyons near Ogden, Utah. On the whole site conditions and climate throughout the region are unfavorable to both natural and artificial regeneration, particularly the latter. Many questions on season of planting, site preparation, planting technique, age and type of stock to use, etc., need to be answered before satisfactory results can be hoped from attempts at abetting natural restocking through artificial means. In addition to the problems of actual field planting and seeding, those in connection with operation of the regional nurseries at McCall and Tony Grove will also need attention. The development of husky root systems in nursery stock and of drought resistance in seedlings is of paramount importance right now.

EFFORTS AND PROGRESS IN SOLUTION OF FOREST MANAGEMENT PROBLEMS

Progress in successful management of forest lands in this region is dependent on the thoroughness and rapidity that solutions can be found to the problems briefly outlined above. In many instances only careful and detailed research can provide satisfactory answers.

Investigative work in forest management by the Intermountain Station was undertaken in 1931 but, due to lack of funds and personnel, studies to date have been conducted only in the ponderosa pine type, and have been principally silvicultural in nature. Nevertheless, a substantial amount of information which will serve as a foundation for successful management of ponderosa pine stands has been gained already.

SILVICULTURAL INVESTIGATIONS

In the silvicultural field the principal lines of work have been methods of harvest cuttings, natural regeneration, and stand improvement.

1. Methods of cutting: The methods of cutting studies have resolved into investigations of (a) actual results of various methods of harvest on permanent sample plots established for this purpose; (b) remeasurement of old permanent sample plots on cut-over areas; (c) extensive surveys of national forest, state and private cut-over lands; and (d) measurement of virgin stands. The first study has yielded information on (1) the nature of changes in stand structure resulting from various marking methods, (2) wood waste under current standards of utilization, (3) logging damage and early mortality in reserve stands, and (4) incidence of post-logging reproduction. The second and third studies, by shedding light on growth, mortality, and reproduction, have served as check on past cutting practices and a guide in planning future ones. From the research standpoint these have been important in leading to the specific problems of ponderosa pine silviculture, especially regeneration. The fourth study has contributed to the methods of cutting investigations by yielding information on growth and susceptibility to mortality of different classes of trees. Current accomplishments in this field include:

a. An analysis of the logging damage and other losses associated with "economic" selective logging in central Idaho. This analysis showed that caterpillar logging destroyed 40 percent of the seedlings and saplings, and burning of piled slash caused an additional loss of 17 percent. Probably a truer picture of the changes wrought by logging can be obtained by comparisons based on stock-quadrat survey data rather than on total number of seedlings and saplings. On the basis of this survey (employing 2-milacre quadrats) 77 percent of the areas was stocked just prior to logging and 51 percent immediately after. Of this reduction of 26 percent, less than 4 percent was due to actual cutting, about 9 percent to slash burning, and the balance of 13 percent largely to skidding. Of the reserve trees 4 inches in diameter and over, logging destroyed 10 percent, slash burning 5 percent, and bark beetles 4 percent. The destruction of reproduction is considered of particularly serious moment because of the difficulty of obtaining prompt and adequate stocking in this type; likewise the loss in larger trees is of some significance because it means not only actual volume waste but also reduction in the most thrifty portion of the stand. Conditions on the ground indicate that losses in both trees and reproduction could be reduced materially through the exercise of a modicum of care in felling, in slash disposal, and in the location of skid trails.

b. A bark beetle survey of the experimental forest in Boise Basin, Idaho, furnishing an estimate of losses occurring in the past two years. This survey showed that the average annual loss on 2,182 acres of virgin forest was 110 ponderosa pine trees

representing 169,107 board feet. In per acre volume loss this is equivalent to about 80 board feet or about 0.6 percent of the total volume of the stand. This is also very nearly equal to the mean annual loss from the same cause on the Payette National Forest plots during the period 1913-1931. Losses in cut-over stands are disproportionate and heavier, pointing to the need of shorter cutting cycles, better mortality prediction and thrift definition in residual stand tree classes, and of rapid reduction of the negative growth element in the stands.

2. Natural regeneration: In the field of natural regeneration very material progress has been made in finding and evaluating the important direct and indirect factors responsible for success or failure of natural regeneration as related to methods of harvesting ponderosa pine. These studies have included (1) determination of quantities of seed by various classes of trees and stands, (2) limits of effective seeding, (3) the importance of rodent influence, and (4) the relations of germination and survival to character of seedbed, to aspect, and to shade. Accomplishments during the past year include:

a. An analyses of both cone crop records and catch of seed in traps showing that in good seed years there is no dearth of seed supply reaching the ground. Total ponderosa pine seed fall of 1936 averaged 173,000 per acre in virgin forest, 307,000 in selectively cut stands (with average residual volumes of about 6,000 board feet) and 160,000 in 60-year-old second-growth stands. This resulted in 1937 in the germination of 2,966 seedlings per acre in virgin forest and 5,052 per acre on selectively cut areas. Of these initial numbers only 93 and 558 respectively survived at the end of the year. Rodents were found to account in large measure for the consumption of seed and to a lesser degree the destruction of new seedlings. Insolation and drought were the important physical causes of high mortality. Drought kill was much greater under natural conditions than in the enclosure seedbeds, presumably because plant competition in the latter had been reduced to a minimum.

The natural regeneration studies definitely point to the importance of leaving an adequate reserve stand that is capable of producing large quantities of seed. For the moment it appears that good silviculture from the regeneration standpoint in the ponderosa pine stands of central Idaho will consist mainly of reducing logging losses to a minimum and providing for a sufficient source of sound seed. From year to year summer drought conditions of so great severity can be expected that only after a fortuitous combination of a heavy seed year followed by a favorable summer can one hope for anything like a general catch of seedlings surviving the vicissitudes of the early years. In the meantime the build-up of seedling numbers from heavy seed crops like that in 1936 will be relatively small, though important, largely serving to offset

subsequent mortality in older reproduction. To be sure, elimination of plant competition would constitute a means of increasing seedling survival, but critical conditions of slope and soil in central Idaho appear to limit its application to very local areas.

3. Stand improvement: In the field of stand improvement contributions have been made to the knowledge of thinning and pruning practices in second-growth ponderosa pine.

Recent accomplishments in this field include:

a. An analyses showing that crop trees in sapling and pole stands suffered considerable injury from snow in the first two winters following thinnings. On some plots, damage to crop trees in the 2-inch diameter class exceeded 15 percent of the total numbers in that class. Third winter losses were negligible. Amount of injury had an inverse relationship to diameter, being negligible above 5 inches. However, initial snow damage in thinnings of young stands should not be regarded as serious since there are usually a sufficient number of uninjured crop trees and/or "nurse" trees to form a full stand at the end of the rotation.

b. Analyses indicating that pruning holds great promise as a profitable stand improvement measure in second-growth ponderosa pine. Natural pruning makes such slow progress on poor site III's and good site IV's (which comprise the bulk of the sites in central Idaho) that practically no clear height obtains in the first hundred years; moreover, persistence of dead branches may exceed 50 years or even considerably longer. Density of stand does not affect rate of natural pruning markedly but does influence the rate of dying of the lower limbs. A large percentage of the variation in live crown length is accounted for by total height of tree and its average spacing. For codominant and dominant trees of even-aged near-normal stands (with heights ranging from 30 to 90 feet and average spacing from 3 to 20 feet) this relationship is summarized in the following multiple regression equation: $X = .447H - 1.071S + 10.456$, where X = height to lowest live limb, H = total height of tree in feet, and S = average spacing in feet (obtained by averaging measurements from bole of sample tree to three nearest competing trees).

c. A time study showing that pruning the butt logs (first 17 feet) of trees 5, 6, and 7 inches in diameter consumes on the average 3.52, 3.95, and 4.66 minutes, respectively. In an 8-hour day one man can prune from 50 to 60 trees of these sizes, depending on the density of the stand, topography, and some other minor factors. Sharp tools of the proper kind in the hands of a good man hold the secret to rapid pruning. Out of 8 different tools, a cruiser's axe or similar impact tool was the fastest tool in pruning from the ground up to seven feet (this is the maximum height to which an average man can conveniently reach on sloping topography), and when in the hands of an experienced axeman, it does an acceptable job. A pole saw with a sectioned handle and a stiff, curved 14-1/2-

inch drag stroke cutting edge with seven 3/16-inch teeth to the inch was the fastest to use in pruning from 7 to 17 feet. A hand saw with a pistol grip handle, a slightly curved blade, and a 10-1/2-inch drag stroke cutting edge supporting five 7/32-inch teeth to the inch and used from a ladder was next best for this height. Pruning in general cannot be performed in one operation at one time on ponderosa pine trees below 4 inches in diameter on most sites in central Idaho because of the material reduction of green crown in trees below this size. Length of live crown is naturally governed by density-site relationships.

ARTIFICIAL REGENERATION

In the field of artificial regeneration, studies have been directed at urgent problems in (1) seed collection, extraction, storage, and testing of seed quality, (2) nursery culture, (3) field planting, and (4) artificial seeding. Significant achievements during the past year include:

a. A field test for predicting maturity of ponderosa pine seed. This test involved the determination of specific gravity of freshly-gathered cones. It was found that cones floating in a test liquid of a 50-50 mixture of kerosene and linseed oil may be adjudged sufficiently ripe to gather in central Idaho. Viability tests on seed gathered at different periods in the season showed that date of gathering is extremely important from the standpoint of seed quality, and that ocular methods of determining maturity of seed in dry-fruited species like ponderosa pine are as a rule unsatisfactory.

b. Nursery sowing tests. Fall sowing of ponderosa pine was found to be very much superior to spring sowing, partly because of delayed germination in spring-sown bed, and partly because of more severe bird and mouse depredations on spring-sown seed. Mulches of aspen, litter, fir boughs, and pine needles in addition to conserving soil moisture exercised a decided protective effect in spring sowings.

c. Field planting tests of nursery stock. Planting in deep holes (about 18 inches - equivalent to subsoiling) raised survival by a significant amount. Transplant stock did better than seedbed stock, although size of seedling has probably as much influence as age insofar as subsequent growth is concerned. As much as 90 percent of the variation in seedling height growth is accounted for by the initial height of the planted stock. The type of stock with roots pruned to about 8 inches now obtainable from nurseries in neighboring regions appears unsuitable for many central Idaho sites. Pruning at a greater depth seems desirable.

d. Artificial seeding tests of ponderosa pine. Protection of seed spots with 1/3-inch mesh hardware cloth cages or cones appears to give seed adequate protection and result in satisfactory

survival. Sowing seed without protection, except under chance circumstances is a waste of seed. Spring seeding is not suitable in central Idaho, because soil moisture conditions normally prevent complete and early germination of seed.

FIRE PROTECTION INVESTIGATIONS

In the field of fire protection two lines of investigation are under way at the present time, namely, (1) fire effects on timber stands and reproduction, and (2) fire behavior and control.

In the first group of studies, the immediate damage from volume loss, destruction of reproduction, and induced accelerated erosion were determined during the period 1932-35. During the past year additional information was obtained on delayed effects of fire in partial and complete burns on cut-over and virgin areas. In the first five years after fire, the injured stands showed a variable but generally serious loss of trees, chiefly from bark beetle attack. Heavy attack had subsided, however, though occasional trees are still dying. Growth of trees has been slow; foliage on green portions of crowns is normal again but the total crown area was permanently reduced by the fire. Where the stand was not entirely killed, an average of 202 new seedlings per acre was present at the end of the second year following fire, and their survival and growth has been fair. Later seeding has been so sparse that until 1937 it has been insufficient to offset mortality. Most portions of the burn have revegetated with a heavy cover of brush and weeds, and are rapidly assuming the appearance of an old-burn brush field. In general the vegetation density is already twice as heavy as that of the ground cover in corresponding virgin forest.

In the second group of studies little is being done due to lack of funds and personnel. Earlier studies in rate of held line construction have been abandoned for the present. A 5-year cooperative study on the use of wood cylinders as a supplement to existing schemes of fire danger prediction culminated during the past year with a compilation of all these records and preparation of a report. Until funds are obtained no further studies are contemplated, but cooperation to the region will be given by way of calibrating over a hundred sets of wood cylinders and several duff hygrometers. Assistance will also be given in devising more efficient schemes of fire danger prediction.

WHAT STILL REMAINS TO BE DONE

Of the major forest types in the region only ponderosa pine is receiving anything near adequate attention silviculturally or otherwise. In this type the Intermountain Forest and Range Experiment Station is expending all available energies to hasten the fruition of its investigations which will provide solutions in a material way to many problems, but the task is hardly begun and the forces available for this are far too small. Elsewhere new problems are cropping up along many fronts, while old ones remain unsolved.

The acquisition and donation of gutted lands to the Forest Service is forcing the hand of the administrative organization to do something quick toward restoration of these areas. The small mill situation in the region is entering a critical stage. A dire need exists for a regionwide survey of the timber resources, stage of depletion, and rate of drain in order to make possible the formulation of intelligent plans for management of existing timber resources. Fire control is literally hedged with problems. In the meantime, on private lands pressure for liquidation is encouraging rapid harvesting of timber and on national forests sales continue on the basis of the best available but still sketchy knowledge of silvicultural requirements of species. It is too much to hope that administrative forces can cope with all these problems without fortification by a veritable mass of new information. Finally, a more vigorous action program needs to be prosecuted to insure a change of the shrinking timber supply to an increasing, ever-renewable resource which will provide to the public not only raw materials and employment but also a profitable use of those portions of the wild lands capable of supporting timber stands. It may well be that when distant stands of virgin timber become exhausted, a major portion of the region's future supplies of saw timber will have to be grown largely on lands within the region.

R - INT
Investigative Program
1937

March 15, 1938

PREFACE TO RANGE INVESTIGATION PROJECT STATUS SHEETS

At the present time range investigations in the Intermountain region are being conducted at several locations representing major geographic, and to a certain extent, ecologic units. (1) Summer range problems are being investigated mainly on the Manti National Forest near Ephraim, Utah, and on the Boise National Forest, 35 miles southeast of Boise, Idaho; (2) salt-desert shrub winter range, at the Desert Branch Station 50 miles west of Milford, Utah; (3) sagebrush-grass spring-fall range, at the U. S. Sheep Experiment Station near Dubois, Idaho; and (4) artificial revegetation, at Ogden, but with other work centers at the Great Basin and Wasatch Branch stations in Utah; at the U. S. Sheep Experiment Station and Arrowrock Substation in Idaho; with trial centers near Wells and Paradise Valley in Nevada; with miscellaneous tests in southwestern Wyoming; and plant breeding studies at Logan, Utah, cooperative with the Bureau of Plant Industry and the Utah Experiment Station.

These investigations have for their purpose the development of measures of range rehabilitation and methods of grazing management and land utilization necessary for sustained forage production. To accomplish these ultimate objectives, the following main lines of study (projects) are being pursued, each having contributory but distinct secondary objectives:

1. Plant Growth and Forage Yield.

    a. Effects of climatic factors on plant growth.

    b. Seasonal and annual forage yields.

2. Plant Community Studies.

    a. Successional status of range vegetational types.

    b. Control of undesirable plants.

3. Plant Species Studies.

    a. Physiological studies of range plants.

4. Range Use.

   a. Methods of grazing.

   b. Season and intensity of grazing.

   c. Utilization standards.

   d. Wildlife influences.

   e. Palatability (forage preference).

   f. Clipping studies.

5. Range Inventories.

   a. Vegetative survey of the Ephraim Canyon watershed.

6. Artificial Revegetation.

   a. Quality and condition of range soils suitable for reseeding.

   b. Location, extent, and description of range areas that require artificial revegetation.

   c. Species adaptation.

   d. Methods of revegetation. (A number of specific studies co-operative with Influence Division.)

   e. Cost and practicability of artificial revegetation.

   f. Seed studies.

   g. Plant breeding - selection and hybridization.

7. Experimental design and methodology.

   a. Experimental designs in range investigations.

   b. Methodology in range investigations.

RR - INT
Management
Summer Range

March 15, 1938

EFFECTS OF CLIMATIC FACTORS ON PLANT GROWTH - SUMMER RANGES

FIELD DIVISION: Range investigations.

FUNCTIONAL PROJECT: Plant growth and forage yields. (WORK PROJECT: Summer range.)

SUBPROJECT: Effects of climatic factors on plant growth. (LINE PROJECT: Effects of climatic factors on plant growth.)

PURPOSE OF WORK: To determine for the summer ranges in Utah (a) the relative importance of the various climatic factors on and the extent to which they influence growth and forage production, and (b) adjustments in range management that may be necessary to compensate for the variations in plant growth and production.

REVIEW OF PAST WORK: Results prior to 1923 were published as U.S.D.A. Bulletin 1405. Climatic records which have been maintained since 1914 in three major vegetational zones of the Wasatch Plateau in Utah show not only wide variations between zones, but extreme fluctuations within zones, both in seasonal and yearlong climatic conditions. Extremes of climate since they affect both the time and length of grazing season and the quantity of forage produced are important to proper range management. Other exigencies, however, have led to practices of making both range management and livestock handling conform very closely to set calendars of operation. An analysis of these fluctuations and their influence on the inception of growth in the spring, and the rate and quantity of forage production bears out the need of certain elasticity in range management plans in order to prevent injury to the range in unfavorable years. Phenological observations made since 1925 of important range plants in each of the major vegetational zones show that range readiness may vary as much as 47 days in the same zone. These observations further indicate that vegetational readiness or other stages of plant development can be forecast with a high degree of accuracy from observations on date of snow recession, inspection of growth or other early stages of plant development.

ACCOMPLISHMENTS DURING THE PAST YEAR: The climatic data from four stations for a 20-year period, 1914-1934, were summarized and reported in the Monthly Weather Review, 65:291-301,1937 in an article entitled, "Climate of the West Front of the Wasatch Plateau in Central Utah." The climatic factors, governed by altitude, make for distinct plant zones. These are designated as the pinyon-juniper, 5,200 to 6,500 feet; oakbrush, 6,500 to 8,000 feet; aspen-fir, 7,500 to 9,000 feet; and spruce-fir, 9,000 to 11,000 feet in elevation. Average annual precipitation for these zones is 11.70, 17.51, 29.48, and 28.01 inches, respectively. Of these totals, roughly 45, 60, 70, and 80 percent, respectively, come as snow during the season November 1 to April

30, a large part of which is lost as run-off from melting snow. Ordinarily the soil to a depth of six inches is driest during July and August. At greater depths the driest point is not reached until September or October at which time the main growing season is past. During protracted drought periods the soil moisture even down to a depth of 2 feet may be reduced below the point of availability to the plants. The wide departures from these averages and particularly the long periods of drought which recur on the summer ranges of this region represent a major problem in range management.

PLANS FOR NEXT YEAR: To be continued as planned except for slight changes in soil moisture studies. Effort will be made to study rate and depth of infiltration of summer rains.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and Ira Clark.

RR - INT
Management
Desert Range

March 15, 1938

EFFECT OF CLIMATIC FACTORS ON PLANT GROWTH
SALT-DESERT SHRUB RANGES

FIELD DIVISION: Range investigation.

FUNCTIONAL PROJECT: Plant growth and forage yield. (WORK PROJECT: Salt-desert shrub winter range.)

SUBPROJECT: Effect of climatic factors on plant growth. (LINE PROJECT: Effect of climatic factors on plant growth.)

PURPOSE OF WORK: To determine for the salt-desert shrub ranges (a) the relative importance of the various climatic factors on and the extent to which they influence plant growth and forage production, and (b) adjustments in range management that may be necessary to compensate for the variations in plant growth and production.

REVIEW OF PAST WORK: Climatic records taken at the Desert Range Branch Station since 1933 indicate that climatic factors on the semidesert ranges exhibit extreme variability. Precipitation is very sporadic and varies greatly from month to month and from season to season. During the summer of 1933 (June to October) rainfall was only 0.33 of an inch, whereas, during the same period in 1935 it was 4.00 inches. Summer storms, often local, frequently occur as torrential down pours. Fluctuation in climate has long been recognized as playing an important role in forage production. On the semidesert ranges current forage growth varies widely between dry and wet years, and due to restricted distribution of storms equally wide variations may occur within a radius of 20 miles during a single year. Utilization of the major portion of the winter range is also dependent on water from snow, but snow is not always available on areas supporting ample forage.

The relationship of climatic factors, especially precipitation, to the growth and use of forage indicates that practical range management must be sufficiently flexible to meet the vicissitudes of the climate.

ACCOMPLISHMENTS DURING PAST YEAR: Preliminary analysis of the climatic factor and plant growth data indicates that the season of precipitation influences materially the quality as well as the quantity of forage. Different plant species react differently to seasonal precipitation. Following seasons of favorable winter and spring precipitation, desert shrubs and the perennial bunchgrasses such as Indian ricegrass (Oryzopsis hymenoides), needlegrass (Stipa comata and S. arida) and bluebunch wheatgrass (Agropyron spicatum)

flourish and produce a good quantity of forage and abundant seed, but following a dry winter and spring these plants make only moderate growth and seldom produce heavy seed crops. Abundant summer precipitation stimulates the growth of grama grass (Bouteloua gracilis), galleta grass (Hilaria jamesii) and on overgrazed ranges Russian-thistle (Salsola pestifer) responds and grows luxuriantly.

PLANS FOR NEXT YEAR: This subproject will be continued as previously planned. Data on plant growth and climate for the past five years will be analyzed and published.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and Selar S. Hutchings.

RR - INT
Management
Sagebrush-grass Range March 15, 1938

EFFECT OF CLIMATIC FACTORS ON PLANT GROWTH SAGEBRUSH-GRASS SPRING-FALL RANGE

FIELD DIVISION: Range investigations.

FUNCTIONAL PROJECT: Plant growth and forage yield. (WORK PROJECT: Sagebrush-grass spring-fall investigations.)

SUBPROJECT: Effect of climatic factors on plant growth. (LINE PROJECT: Effect of climatic factors on plant growth.)

PURPOSE OF WORK: To determine for the sagebrush-grass spring-fall ranges (a) the relative importance of the various climatic factors on and the extent to which they influence plant growth and forage production, and (b) adjustments in range management that may be necessary to compensate for the variations in plant growth and production.

REVIEW OF PAST WORK: Records of the more important climatic factors and plant basal area continuous since 1923 and records of phenology and plant density continuous since 1932,, permit some very general conclusions concerning climatic factors and plant growth to be drawn.

Viscissitudes of climate as they affect the rate and character of plant growth have been long recognized as important from the standpoint of management of native ranges. Similar stages of plant development have been found to vary 40 days in the time of their occurrence. Flower stalk production is very sporadic on sagebrush-grass ranges and the production of viable seed is relatively infrequent. Summer growth cannot be relied upon.

Severe droughts similar to that occurring in 1934 result in severe and more or less permanent damage even to the stands of perennial grasses under total protection. This damage is not overcome even during a good year following the year of drought. These results were published as a manuscript in Ecology in October 1937.

ACCOMPLISHMENTS DURING THE PAST YEAR: For the first time since the 1934 drought, basal area of Agropyron spicatum, the principal grass species, began to increase. Other plant species exhibited but little change from 1936. Flower stalks production and height growth of grasses and weeds were slightly below average and virtually no viable seed was produced by any species.

PLANS FOR NEXT YEAR: This subproject will be continued in 1937 without change. Some attention may be given under "experimental design and methodology" studies to the possibility of randomization in the selection of plants for plant development observations.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and J. F. Pechanec.

RR - INT
Management
Summer Range

March 15, 1938

SEASONAL AND ANNUAL FORAGE YIELDS ON SUMMER RANGES

FIELD DIVISION: Range investigations.

FUNCTIONAL PROJECT: Plant growth and forage yields. (WORK PROJECT: Summer range.)

SUBPROJECT: Seasonal and annual forage yields. (LINE PROJECT: Seasonal and annual forage yields.)

PURPOSE OF WORK: To determine for summer range in Utah the extent of variation in the quantity and quality of seasonal and annual herbage production by the more important forage species.

REVIEW OF PAST WORK: Results prior to 1923 were published as U.S.D.A. Bulletin 1405.

Total forage production from year to year may vary from 120 percent above to 77 percent below a long time average.

ACCOMPLISHMENTS DURING PAST YEAR: These data summarized to 1932 were submitted for publication last year.

PLANS FOR NEXT YEAR: This subproject will be continued for the most part as previously planned.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and Ira Clark.

RR - INT
Management
Desert Shrub

March 15, 1938

SEASONAL AND ANNUAL FORAGE YIELDS ON SALT-DESERT SHRUB RANGES

FIELD DIVISION: Range investigations.

FUNCTIONAL PROJECT: Climate and plant growth. (WORK PROJECT: Salt-desert shrub winter range.)

SUBPROJECT: Seasonal and annual forage yields. (LINE PROJECT: Seasonal and annual forage yields.)

PURPOSE OF WORK: To determine for salt-desert shrub the extent of variation in the quantity and quality of seasonal and annual herbage production by the more important forage species.

REVIEW OF PAST WORK: Data obtained from 10 plant growth stations, distributed over winter ranges in western Utah, indicate that general herbage production fluctuates considerably from year to year and from one locality to another. Variations of more than 300 percent in herbage production, which occur between dry and favorable years, have a profound influence on the number of livestock which the range can support. Forecast of poor forage years, well in advance of grazing dates, would aid the stockmen by providing an opportunity to make suitable adjustments in numbers of stock scheduled for the winter ranges and to obtain supplemental feeds.

ACCOMPLISHMENTS DURING THE PAST YEAR: Records were continued.

PLANS FOR NEXT YEAR: Records at the present stations will be continued. In addition, the number of stations will be increased and the territory enlarged to include all of western Utah and central Nevada.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and Selar S. Hutchings.

RR - INT
Management
Sagebrush-grass Range

March 15, 1938

SEASONAL AND ANNUAL FORAGE YIELDS ON SAGEBRUSH-GRASS SPRING-FALL RANGES

FIELD DIVISION: Range investigations.

FUNCTIONAL PROJECT: Plant growth and forage yield. (WORK PROJECT: Sagebrush-grass spring-fall investigations.)

SUBPROJECT: Seasonal and annual forage yields. (LINE PROJECT: Seasonal and annual forage yields.)

PURPOSE OF WORK: To determine for sagebrush-grass spring-fall range the extent of variation in the quantity and quality of seasonal and annual herbage production by the more important forage species.

REVIEW OF PAST WORK: Studies of plant density fluctuations as indicative of yield were begun in 1932. Studies of seasonal and annual quantities of herbage produced were begun in 1935. Investigations on the chemical nature of the herbage produced were begun during the 1937 field season.

Forage production as indicated by density has been found to vary from 60 percent above to 65 percent below normal with two or more successive deficient years occurring.

Seasonal herbage production of Agropyron spicatum and Balsamorhiza sagittata follows the typical S-shaped curve characteristic of height growth except that there are increases in dry weight of the herbage following the cessation of height growth. Under conditions similar to 1936, and where grazing begins when the plants are 2 inches in height, only 12 to 36 percent of the total seasonal herbage production is available for grazing on those paddocks grazed first in the rotation. Thus, when stocked on the basis of end season production, paddocks grazed very early in the season may be very heavily utilized.

Total herbage production of Agropyron spicatum in 1936 was 29.8 percent below that of 1935.

ACCOMPLISHMENTS DURING P A S T YEAR: Seasonal herbage production trends corroborate those of 1936 in indicating that very early season removal of herbage from Agropyron spicatum does not retard total seasonal herbage production.

PLANS FOR NEXT YEAR: This subproject will be continued in 1938 without change.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and J. F. Pechanec.

RR - INT
Management
Summer Range

March 15, 1938

SUCCESSIONAL STATUS OF SUMMER RANGE VEGETATIONAL TYPES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Plant community studies. (WORK PROJECT: Summer Range.)

SUBPROJECT: Successional status of range vegetational types. (LINE PROJECT: Successional status of range vegetational types.)

PURPOSE OF WORK: To determine for summer range vegetational types (a) the relation of the structure of the plant communities now occupying extensive range areas to their potential structure under protection or proper grazing management, and (b) the rapidity with which changes take place.

REVIEW OF PAST WORK: Ninety-six quadrats, 71 major plots and 7 intensively mapped areas established since 1914 in the three major vegetational zones of the Wasatch Plateau have been re-mapped and reestimated at regular intervals to determine the change in native plant cover under varying degrees of deterioration, erosion, and intensity of grazing. Results to 1922 have been published in U.S.D.A. Bulletins 791 and 1405.

Compilation and analysis of more recent data (up to 1935) have been started. Seeding habits, seed production, seed dissemination and germination under various conditions of storage, temperature and moisture relationships for 55 important range species have been determined for a period covering four years. The phase dealing with seed germination studies was published in Botanical Gazette 98:243-269, 1936. A report covering the other phases has been submitted for publication.

ACCOMPLISHMENTS DURING THE PAST YEAR: Seedling survival of grasses was found to be much lower than for many of the more important weed species, only 36 percent of all grass seedlings surviving the first year while for the more important weeds survival ranged from 71 to 100 percent. For the most common grasses the average length of life of plants surviving through the first seedling year is about four years. Weeds have about the same length of life as grasses. Less than 5 percent of the perennial grasses and weeds present when quadrats were established lived throughout the 10 or 15 years covered by these studies.

PLANS FOR NEXT YEAR: Observations and mapping will be continued in accordance with regular schedule.

DATE OF COMPLETION: A report covering field work to 1937 should be completed in 1938. To further study climatic influences and management practices this subproject should be continued for an indefinite period.

ASSIGNMENT: George Stewart, Raymond Price, and Ira Clark.

RR - INT
Management
Bunchgrass-Granitic Soil

March 15, 1938

SUCCESSIONAL STATUS OF BUNCHGRASS-GRANITIC SOIL RANGE VEGETATIONAL TYPES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Plant community studies. (WORK PROJECT: Bunchgrass-granitic soils - Idaho.)

SUBPROJECT: Successional studies of range vegetational types. (LINE PROJECT: Successional studies of range vegetational types.)

PURPOSE OF WORK: To determine for bunchgrass-granitic soil vegetational types (a) the relation of the structure of the plant communities now occupying extensive range areas to their potential structure under protection or proper grazing management, and (b) the rapidity with which changes take place.

REVIEW OF PAST WORK: Inspections and surveys during the period 1929-1931 showed that the serious erosion problem on the Boise River watershed was largely the result of excessive grazing of the forage resource. A system of 100 one-meter quadrats and 105 25-square-meter plots was established in connection with 11 enclosures to study the natural vegetation of the watershed. Preliminary analyses of data obtained from these plots indicate that (1) the natural plant cover, when not weakened by excessive grazing, provides adequate watershed protection, (2) that on much of the area carefully controlled grazing will insure satisfactory recovery and maintenance of the natural plant cover, but (3) on the seriously depleted foothill ranges natural revegetation will not produce satisfactory stands under existing climatic conditions, and artificial revegetation will have to be resorted to. Little exact information was provided concerning the course and rate of successional succession under the varying conditions by these early analyses.

ACCOMPLISHMENTS DURING THE PAST YEAR: All plots were remeasured during 1937 and detailed analysis of the changes in plant cover during the 6-year period will be made as soon as possible.

PLANS FOR NEXT YEAR: Annual measurement of key plots will be continued for correlation with climate and biennial measurement of all plots to determine successional trends.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: C. Kenneth Pearse.

RR - INT
Management
Desert Shrub

March 15, 1938

SUCCESSIONAL STATUS OF SALT-DESERT SHRUB RANGE VEGETATIONAL TYPES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Plant community studies. (WORK PROJECT: Salt-desert shrub winter range.)

SUBPROJECT: Successional status of range vegetational types.(LINE PROJECT: Successional status of range vegetational types.)

PURPOSE OF WORK: To determine for salt-desert shrub range vegetational types (a) the relation of the structure of the plant communities now occupying extensive range areas to their potential structure under protection or proper grazing management, and (b) the rapidity with which changes take place.

REVIEW OF PAST WORK: General surveys of the winter ranges in western Utah and Nevada indicated that the plant cover had been reduced 34 percent and the forage value had declined 62 percent as a result of continued heavy and unregulated grazing. Forage volume on typical winter range lands in western Utah subjected to proper use for a period of 4 years almost doubled, and on the favorable sites herbage production was increased 2.3 times. Areas totally protected for periods ranging from 2 to 5 years show marked increase in plant vigor, plant cover, and soil stabilization. Forage production on these areas increased from 1.5 to 2.5 times as compared to the open range. Herbage production per plant of ricegrass (Oryzopsis hymenoides) on the protected enclosure was 3 to 6 times greater than that on the open unregulated range.

ACCOMPLISHMENTS DURING THE PAST YEAR: Four additional pastures were constructed at the desert experiment station and 35 enclosures were located on the winter ranges, primarily in Nevada. The enclosures established in 1932 were mapped and the data analyzed. Remarkable improvement of plant cover and plant vigor has resulted. Russian-thistle, abundant on the open range, is almost totally lacking on the protected areas. Seedling production and survival of the better forages average from 4 to 7 percent for the various plant species on the protected areas as compared to less than 2 percent on the open range. In Pine Valley the total plant cover on managed range has increased 42.6 percent, grasses 118 percent, and good forage shrubs 36.1 percent as compared to the open range.

PLANS FOR NEXT YEAR: Work will be continued as outlined, and the past 5 years' data will be analyzed and published.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and Selar S. Hutchings.

RR - INT
Management
Sagebrush-grass Range

March 15, 1938

SUCCESSIONAL STATUS OF SAGEBRUSH-GRASS
SPRING-FALL VEGETATIONAL TYPES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Plant community studies. (WORK PROJECT: Sagebrush-grass spring-fall investigations.)

SUBPROJECT: Successional status of range vegetational types. (LINE PROJECT: Successional status of range vegetational types.)

PURPOSE OF WORK: To determine for sagebrush-grass spring-fall range vegetational types (a) the relation of the structure of the plant communities now occupying extensive range areas to their potential structure under protection or proper grazing management, and (b) the rapidity with which changes take place.

REVIEW OF PAST WORK: A series of paired enclosures, fenced and grazed, located on the sagebrush-grass ranges throughout Utah and at the U. S. Sheep Experiment Station in Idaho reveal that revegetation under total protection is extremely slow in this type. This retarded recovery under protection of many of the areas may be attributed to the almost total extinction of desirable grass and forb species leaving the area almost totally controlled by big sagebrush (Artemisia tridentata). In many cases the presence of sagebrush utilizing all of the available soil moisture effectively prevents successful speedy aggression by the more desirable species.

ACCOMPLISHMENTS DURING THE PAST YEAR: A severe set-back to the progress of recovery as a result of the 1934 and 1936 drought is evident from all the areas studied in 1937. So evident was this that after five years' total protection many of the areas exhibited little if any progress toward recovery.

PLANS FOR NEXT YEAR: Project will be continued as planned.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and J. F. Pechanec.

RR - INT
Management
Sagebrush-Grass Range March 15, 1938

CONTROL OF UNDESIRABLE PLANTS ON SAGEBRUSH-GRASS SPRING-FALL RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Plant community studies. (WORK PROJECT: Sagebrush-grass spring-fall investigations.)

SUBPROJECT: Control of undesirable plants. (LINE PROJECT: Control of undesirable plants.)

PURPOSE OF WORK: To determine for sagebrush-grass ranges the best methods (a) for preventing the increase of sagebrush and other undesirable plants, and (b) for the removal of these undesirable species on ranges where they have already become too abundant.

REVIEW OF PAST WORK: From pasture studies on the U. S. Sheep Experiment station it is evident that the best method of control of sagebrush is by proper grazing. Under fall grazing, stands of sagebrush are being slowly replaced by grasses and weeds.

In cooperation with the Fremont County Woolgrowers Association and the state of Idaho an experiment begun in 1932 on state lands indicates that on certain areas the removal of sagebrush by fire may in many cases nearly double the forage production. It is apparent, however, that certain tuft-forming grass species are injured to some extent by the use of fire. This, together with the fact that removal of sagebrush by fire on areas where the remaining grass stand is very light or where no provision is being made for subsequent proper management may prove ineffectual in improving range conditions, or even detrimental, indicates the necessity of a thorough inspection of areas upon which the use of fire for sagebrush removal is being recommended.

Studies were begun in 1936 on the U. S. Sheep Experiment Station ranges to determine the best management after sagebrush removal as well as indicating method of handling lands to be burned.

An investigation of the effect of the use of fire for sagebrush removal upon soil properties conducted on several controlled and uncontrolled burns indicates that in general nitrogen content, organic matter content, soil acidity and moisture equivalent were unaffected. For some specific areas a slight decrease in organic matter and nitrogen content with a slight increase in acidity could be found but this was by no means general.

ACCOMPLISHMENTS DURING THE PAST YEAR: Final inspection of the project being conducted in cooperation with the Fremont County Woolgrowers was made and a report on the results for journal publication was completed.

Additional areas of the U. S. Sheep Experiment Station range were burned in accordance with an organized plan for the rehabilitation of approximately 13,000 acres.

PLANS FOR NEXT YEAR: The project being conducted in cooperation with the Fremont County Woolgrowers will be discontinued except for periodic inspections. Studies on the U. S. Sheep Experiment Station range for the study of proper management after fire will be continued.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and J. F. Pechanec.

RR - INT
Management
Summer Range

March 15, 1938

PHYSIOLOGICAL STUDIES OF RANGE PLANTS ON SUMMER RANGE

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Plant species studies.(WORK PROJECT:Summer range.)

SUBPROJECT: Physiological studies of range plants. (LINE PROJECT: Physiological studies of range plants.)

PURPOSE OF WORK: To determine for summer range forage species the relative effects of clipping and grazing to varying intensities and at varying seasons upon the seasonal and annual physiological activities of the plant.

REVIEW OF PAST WORK: Carbohydrate studies were initiated in 1932 in cooperation with Dr. E. C. McCarty of Riverside Junior College, Riverside, California. The field work on this phase was completed in 1936. Reports on these investigations have been partially completed. Two completed reports have been submitted to the Washington office for publication and review.

ACCOMPLISHMENTS DURING THE PAST YEAR: A manuscript on the carbohydrate study for mountain bromegrass was submitted to Government Printing Office as U.S.D.A. Technical Bulletin. A second report involving a number of important species has been submitted for review and is in process of final preparation.

PLANS FOR NEXT YEAR: To complete final reports on all phases of past work.

DATE OF COMPLETION: Previous work -- 1938. Needs revision and another start.

ASSIGNMENT: Raymond Price to complete publication.

RR - INT
Management
Sagebrush-Grass Ranges

March 15, 1938

METHODS OF GRAZING ON SAGEBRUSH-GRASS SPRING-FALL RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range Use. (WORK PROJECT: Sagebrush-grass spring-fall investigations.)

SUBPROJECT: Methods of grazing. (LINE PROJECT: Methods of grazing.)

PURPOSE OF WORK: To determine for the sagebrush-grass spring-fall ranges the effect of different methods of grazing management upon sustained forage production, plant species reaction, and animal performance.

REVIEW OF PAST WORK: Investigations begun in 1923 on a series of pastures indicate that: (a) continuous fall grazing if not in excess of 60 percent utilization on key grass species is not detrimental; (b) spring grazing practiced continuously under the approximate intensity commonly used on adjacent open ranges if continued for a 13-year period, results in the almost total extermination of the more valuable weed species and drastic reductions of the more important grass species which are followed by invasion of sagebrush; and (c) fairly heavy grazing consistently during any single period of the spring grazing period when plant growth and development is occurring is determinetal to the maintenance of forage productivity. If fullest sustained use of spring ranges is to be secured, rotation of grazing must be practiced.

During the severe drought of 1934, rotation and rotation-deferred systems in usage on pastures proved superior to continuous spring grazing. There was some indication of the superiority of rotation deferred systems as compared to rotation systems for forage maintenance during drought periods.

ACCOMPLISHMENTS DURING PAST YEAR: Ewes suckling lambs gained more weight under rotation or rotation-deferred pasture grazing systems than under herded conditions on the open range. Ewes pastured under the rotation system made better gains than those under the rotation-deferred system. Lambs gave slightly less gains under pasture conditions than when herded and slightly more gains when pastured under the rotation system than when under rotation-deferred system. These treatment differences in lambs are all very slight and statistically insignificant.

PLANS FOR NEXT YEAR: This project will be continued in 1938 without change.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and J. F. Pechanec.

RR - INT
Management
Desert Range

March 15, 1938

SEASON AND INTENSITY OF GRAZING ON SALT-DESERT SHRUB RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range use. (WORK PROJECT: Salt-desert shrub winter range.)

SUBPROJECT: Season and intensity of grazing. (LINE PROJECT: Season intensity of grazing.)

PURPOSE OF WORK: To determine for salt-desert shrub (a) the maximum use that may be made under sustained-yield management and yielding the maximum of animal products, (b) the relative influence of season and intensity of use on plant growth and forage production, and (c) the relative influence of season and intensity of use on animal production.

REVIEW OF PAST WORK: Eighteen 320-acre pastures established and stocked in 1936-37 and 1937-38 indicate that proper intensity for use is at the rate of .040 forage acre per head per month at the experimental range or approximately 2½ surface acres. Vegetation in pastures stocked heavier than 2½ surface acres per head per month showed a marked decline in plant vigor and total volume of forage produced. Sheep weights closely correlate with intensity of use.

ACCOMPLISHMENTS DURING THE PAST YEAR: Gain in sheep weights closely correlate with intensity of range use. During a 40-day grazing period the average change in weight of sheep under very heavy, moderate and light grazing were found to be -3.45, -.38, +3.76, and +5.98 pounds, respectively. The sheep were confined to 320-acre pastures and because of the absence of snow, water had to be hauled every second day. On properly grazed herd allotment on the experimental range ewes gained an average of 4.57 pounds during a 42-day grazing period and lambs showed a gain of 2.88 pounds. During the 30-day period preceding the entrance into the experimental range the same ewes showed an average loss of 6.18 pounds and lambs a loss of 1.57 pounds. Two herds which alternate every other year between the conservatively used experimental area and the heavily grazed open range show marked contrast in condition of sheep, wool crop, lamb crop, losses, and expenditures for supplemental feed. The herd inside the experimental area during a 42-day grazing period in 1935-36 sheared 1/3 pound more wool per head and produced a 3 percent greater lamb crop than the herd on the open range.

During the winter of 1936-37 these herds exchanged places and the herd which grazed the experimental range for a 72-day grazing period sheared 1-1/3 pounds more wool and produced 5 percent more lambs than the herd which wintered on the open range. During this severe winter the herd on the open range, although provided with $400 worth of supplemental feed suffered the greater loss. By charging actual losses at $10 per head, supplemental feed costs against the remaining herd and difference in production of wool at 30 cents per pound, the average net profit per head was 58 cents greater for the herd maintained on the managed winter range without benefits of supplemental feed.

PLANS FOR NEXT YEAR: Present study will be continued.

DATE OF COMPLETION OF STUDY: Indefinite.

ASSIGNMENT: George Stewart and Selar S. Hutchings.

RR - INT
Management
Sagebrush-Grass Ranges

March 15, 1938

SEASON AND INTENSITY OF GRAZING ON SAGEBRUSH-GRASS RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range use. (WORK PROJECT: Sagebrush-grass Investigations.)

SUBPROJECT: Season and intensity of grazing..(LINE PROJECT: Season and intensity of grazing.)

PURPOSE OF WORK: To determine for sagebrush-grass spring-fall ranges (a) the maximum use that may be made under sustained-yield management and yielding the maximum of animal products, (b) the relative influence of season and intensity of use on plant growth and forage production, and (c) the relative influence of season and intensity of use on animal production.

REVIEW OF PAST WORK: Field work on this subproject begun in 1933 was confined during the first two years to the study of the relative carrying capacities of the pastures being used in the study. Actual intensity studies were not begun until the spring of 1937.

In studying the relative grazing capacities of several areas, it was found that areas must be grazed at the same time by approximately the same number of animals before the relative carrying capacity ratings would be at all comparable. Forage acre requirement per sheep per day was found to vary widely with season of use and intensity of use, frequently for no apparent reasons. The average forage acre requirement under proper use for sagebrush-grass ranges was found to be .00120 forage acre per head per day for spring use.

ACCOMPLISHMENTS DURING THE PAST YEAR: Since vegetational changes are rather slow under semiarid conditions, no record of the effect of intensity of use on range vegetation is available.

Animal performance indicates somewhat the effect of intensity of use. Ewes suckling lambs, grazed for 60 days on pasture areas, changed in weight inversely to the intensity of stocking. Their lambs, although indicating somewhat the same trends evinced but slight treatment differences, possibly indicating that the ewe maintained the milk flow at the expense to her body.

A study of the green feed requirement of pasturage by ewes indicates that approximately 8.97 pounds of feed is required per head per day. The pound requirement varies widely from 4.98 in the early season to 13.57 pounds later in the season. These requirements calculated from forage inventories by the weight estimate method and estimates of intensity of use by the ocular-estimate-by-plot method conform closely to the investigations of Beruldsen and Morgan in Australia.

PLANS FOR NEXT YEAR: Subproject will be continued as planned.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and J. F. Pechanec.

RR - INT
Management
Summer Range

March 15, 1938

UTILIZATION STANDARDS FOR SUMMER RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range use. (WORK PROJECT: Summer range.)

SUBPROJECT: Utilization standards. (LINE PROJECT: Utilization standards.)

PURPOSE OF WORK: To determine for summer range vegetational types (a) proper intensities of utilization for key plant species consistent with individual plant requirements, (b) the proper intensities of use over extensive range areas, and (c) suitable standards for judging the degrees of utilization and condition of native ranges.

REVIEW OF PAST WORK: Two pasture areas in the spruce-fir zone were constructed in 1923 for conducting pasture grazing studies with sheep and cattle. The sheep grazing experiment was concluded in 1929 and the cattle studies in 1932. These studies have been analyzed and progress reports completed.

ACCOMPLISHMENTS DURING PAST YEAR: Grazing studies are being redesigned to be incorporated in new pasture studies. A series of plants of important range forage species have been set out on range allotments for observation.

A range utilization handbook, summarizing existing basic information on range use and setting up tentative utilization standards for the major vegetative types within the region is being prepared in cooperation with Range Management of the Regional Office. This handbook is intended not only to serve as a guide in securing more accurate information and standardizing procedure in determining utilization, but also to aid in eventually setting up standards of utilization for all vegetative types and to assist in formulating specific research studies by pointing out range use problems for which information is lacking.

PLANS FOR NEXT YEAR: New pasture studies will be initiated for both sheep and cattle grazing experiments on forage utilization. Utilization of individual plants of important range forage species will be studied on range allotments.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and Ira Clark.

RR - INT
Management
Desert Range

March 15, 1938

UTILIZATION STANDARDS FOR SALT-DESERT SHRUB RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range use. (WORK PROJECT: Salt-desert shrub winter range.)

SUBPROJECT: Utilization Standards. (LINE PROJECT: Utilization Standards.)

PURPOSE OF WORK: To determine for salt-desert shrub vegetational types (a) proper intensities of utilization for key plant species consistent with individual plant requirements, (b) the proper intensities of use over extensive range areas, and (c) suitable standards for judging the degree of utilization and condition of native ranges.

REVIEW OF PAST WORK: Utilization and plant palatability records to date indicate that on properly utilized range there should be left from 50 to 55 percent of the total current vegetational growth on the major forage species and from 20 to 25 percent of the more palatable plants.

ACCOMPLISHMENTS DURING PAST YEAR: Records of the past season indicate that 2½ to 4 inches of the current growth of ricegrass (Oryzopsis hymenoides) and from 2 to 3 inches of the winterfat should be left at the close of the grazing season to insure the maintenance of these plants. No emphasis is placed on the number of flower stalks to be left because seeds of most semi-desert plants mature and are disseminated prior to the grazing season. Excessive cropping beyond the limits set forth above tends to injure forage and decrease seed production the following year.

PLANS FOR NEXT YEAR: Utilization records will be continued.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and Selar S. Hutchings.

RR - INT
Management
Sagebrush-Grass Range

March 15, 1938

UTILIZATION STANDARDS FOR THE SAGEBRUSH-GRASS SPRING-FALL RANGES.

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range use. (WORK PROJECT: Sagebrush-grass spring-fall range.)

SUBPROJECT: Utilization standards. (LINE PROJECT: Utilization standards.)

PURPOSE OF WORK: To determine for sagebrush-grass spring-fall vegetational types (a) proper intensities of utilization for key plant species consistent with individual plant requirements, (b) the proper intensities of use over extensive range areas, and (c) suitable standards for judging the degree of utilization and condition of native ranges.

REVIEW OF PAST WORK: Investigations begun in 1923 on a series of pastures indicate that for maintenance of the productivity of the sagebrush-grass type provision must be made to reserve enough of the current spring herbage production for fall use. Summer production is too uncertain to rely upon. Under such conditions approximately 70 percent of the current vegetational growth of Agropyron spicatum should be left at the end of the spring grazing season and 40 percent at the end of the fall grazing season.

ACCOMPLISHMENTS DURING THE PAST YEAR: Preliminary current observations together with past experience indicate that the two plant species Agropyron spicatum and Balsamorhiza sagittata may be used as key species for the development of utilization standards on many sagebrush-wheatgrass ranges.

PLANS FOR NEXT YEAR: Pasture studies and investigations on utilization standards will be continued as planned.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and J. F. Pechanec.

RR - INT
Management
Summer Range

March 15, 1938

WILDLIFE INFLUENCE ON SUMMER RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range use. (WORK PROJECT: Summer range.)

SUBPROJECT: Wildlife influence. (LINE PROJECT: Wildlife influence.)

PURPOSE OF WORK: To determine for summer ranges in Utah the influence of wildlife on range management problems and the adjustments necessary in management plans to permit forage production under sustained yield management.

REVIEW OF PAST WORK: In cooperation with the Biological Survey one 40 foot x 40 foot rodent-proof enclosure was constructed in 1931 in each of four main vegetational types. These areas have been maintained as nearly rodent proof as practicable, and study plots mapped and density estimates both within and outside the enclosure have been made at regular intervals. Other work on determination of rodent population, habits, and forage consumption has not been carried out as originally planned since cooperation with the Biological Survey was temporarily suspended.

ACCOMPLISHMENTS DURING THE PAST YEAR: Inactive; need a cooperator from the Biological Survey.

PLANS FOR NEXT YEAR: It is planned to remap and recheck established plots as scheduled, and continue observations on rodent activities.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and Ira Clark. (Cooperation with Biological Survey. Inactive because of lack of personnel.)

RR - INT
Management
Summer Range

March 15, 1938

PALATABILITY (FORAGE PREFERENCE) OF
PLANT SPECIES ON SUMMER RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range Use. (WORK PROJECT: Summer range.)

SUBPROJECT: Palatability (Forage preferences). (LINE PROJECT: Palatability (Forage preferences.)

PURPOSE OF WORK: To determine for Utah summer range types the extent of variations in seasonal and yearly preference of sheep or cattle for various plant species and the factors to which these variations are attributable.

REVIEW OF PAST WORK: Previous work has established general palatability factor values for important plants. The values for most species are found to vary widely with plant types and percentage composition of the plant cover.

ACCOMPLISHMENTS DURING THE PAST YEAR: None.

PLANS FOR NEXT YEAR: This study will be carried out in connection with utilization investigations. During the first year or two observations will be limited to a few of the important forage species. These will be studied throughout the season for a number of plant types in each major plant zone.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: Ira Clark and George Stewart.

RR - INT
Management
Desert Range

March 15, 1938

PALATABILITY (FORAGE PREFERENCE) OF PLANT SPECIES ON SALT-DESERT SHRUB RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range use. (WORK PROJECT: Salt-desert shrub winter range.)

SUBPROJECT: Palatability (Forage Preference.) (LINE PROJECT: Palatability (Forage Preference.)

PURPOSE OF WORK: To determine for salt-desert shrub types the extent of variations in seasonal and yearly preference of sheep for various plant species and the factors to which these variations are attributable.

REVIEW OF PAST WORK: Palatability of the desert range plants differ widely from year to year, being conditioned by climatic factors at the time of grazing, composition of vegetational type, season of use and herd peculiarity. Variations in palatability are noticeable between dry and wet years as well as between fall, winter and spring seasons. Luxuriance of growth and retardation of maturity of the plants influenced by ample precipitation materially lower the desirability of winterfat (Eurotia lanata) and galleta grass (Hilaria jamesii), but increase the palatability of shadscale (Atriplex confertifolia) and blacksage (Artemisia nova). Snow cover and abundant moisture tend to soften the dry, coarse, and rough forage, and increase the palatability of winterfat, grasses and Russian-thistle.

ACCOMPLISHMENTS DURING PAST YEAR: Palatability of desert forage plants decrease as the particular plant species increase in abundance. Ricegrass is highly relished by sheep on areas where it occurs only moderately but when abundant the palatability is much reduced.

PLANS FOR NEXT YEAR: Collection of data will be continued and results of the past five years will be compiled and analyzed.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: Selar S. Hutchings and George Stewart.

RR - INT
Management
Sagebrush-grass Range

March 15, 1938

PALATABILITY (FORAGE PREFERENCE) OF PLANT SPECIES ON SAGEBRUSH-GRASS SPRING-FALL RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range Use. (WORK PROJECT: Sagebrush-grass spring-fall investigations.)

SUBPROJECT: Palatability (Forage preference.) (LINE PROJECT: Palatability (Forage preference.)

PURPOSE OF WORK: To determine for sagebrush-wheatgrass spring-fall types the extent of variations in seasonal and yearly preference of sheep for various plant species and the factors to which these variations are attributable.

REVIEW OF PAST WORK: Observations in connection with the pasture grazing studies indicate that: first, separate palatability tables are necessary for judging spring and fall grazing capacities; second, variations of individual species palatabilities between periods within the same season may be fully as great as the variation between species; and third, variation of palatabilities between years of the same species may also be as great as the variation between species.

That these variations may be attributed to physiological changes within the plant tempered by different climatic conditions is evident but the nature of these reactions which influence directly the differential preference have not been investigated.

ACCOMPLISHMENTS DURING THE PAST YEAR: Further investigations of the factors influencing preference indicate that relative abundance of a single species may be very influential in altering the degree with which it is sought. Likewise, there are rather definite indications of the influence of floristic composition in any area upon the palatability of any single species.

PLANS FOR NEXT YEAR: The extent of these variations and the part that they may play in the proper management of an area will continue to be investigated, together with some attempt at determining some of the chemical characteristics of the plant that may influence seasonal and yearly preference.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and J. F. Pechanec.

RR - INT
Management
Summer Range

March 15, 1938

CLIPPING STUDIES ON SUMMER RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range use. (WORK PROJECT: Summer range.)

SUBPROJECT: Clipping studies. (LINE PROJECT: Clipping studies.)

PURPOSE OF WORK: To determine for summer range plant species or communities the effects of different methods and intensities of clipping upon plant growth and herbage production.

REVIEW OF PAST WORK: The results of work to 1922, involving 11 species and 20 methods of harvesting, are reported in U.S.D.A. Bulletin 1405. The project was revised in 1923 to study more critically some of the methods previously tried out, on a plot system rather than individual plant basis, and supplemented with actual grazing trials. A shrub clipping study involving only snowberry and true mountain mahogany was initiated in 1926 and carried continuously since that time. The data to 1935 have been analyzed and a written report is being completed.

ACCOMPLISHMENTS DURING THE PAST YEAR. Field work on shrub clipping study completed last year.

PLANS FOR NEXT YEAR: Final analysis and preparation of a report covering the work to date should be made this year.

DATE OF COMPLETION: Report should be completed in 1938.

ASSIGNMENT: George Stewart, Raymond Price, and Ira Clark.

RR - INT
Management
Sagebrush-Grass Range

March 15, 1938

CLIPPING STUDIES ON SAGEBRUSH-GRASS SPRING FALL RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range Use. (WORK PROJECT: Sagebrush-grass spring-fall range.)

SUBPROJECT: Clipping studies. (LINE PROJECT: Clipping studies.)

PURPOSE OF WORK: To determine for the sagebrush-grass spring-fall ranges plant species or communities the effects of different methods and intensities of clipping upon plant growth and herbage production.

REVIEW OF PAST WORK: Clippingstudies on native vegetation to determine the effects of continuous, early, intermediate, and late spring clipping were begun in 1934. As measured by basal area changes, clipping during any period in the spring if practiced consistently year after year during the same period is more harmful than fall clipping. Early and intermediate spring clipping are less detrimental than late spring clippings, both from the standpoint of basal area and herbage yield.

ACCOMPLISHMENTS DURING THE PAST YEAR: Definite indications of decreased plant vigor as result of late spring clipping were found. Vegetation on quadrats clipped early in the spring grazing season, beginning when the plants averaged 2 inches in height, were but little less vigorous than the vegetation on fall clipped quadrats.

PLANS FOR NEXT YEAR: Studies are to be continued as planned in 1938.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and J. F. Pechanec.

RR - INT
Management
Summer Range

March 15, 1938

VEGETATIONAL SURVEY OF THE EPHRAIM CANYON WATERSHED

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Range inventories. (WORK PROJECT: Summer range.)

SUBPROJECT: Vegetational and erosion surveys of Ephrain Canyon watershed. (LINE PROJECT: Vegetational and erosion surveys of Ephraim Canyon watershed.)

PURPOSE OF WORK: To make (1) a detailed forage inventory of the amount and condition of the plant cover, (2) an accurate forage type map, and (3) to furnish information on soil erosion, litter cover, and range conditions generally for each forage type present on the Ephraim Canyon watershed.

REVIEW OF PAST WORK: In 1936 an intensive vegetation and erosion survey was made of the entire Ephraim Canyon watershed within the Manti National Forest. This inventory, based on 100 plots per section and covering some 16,700 acres, was made by the point-observation-plot system as developed by Stewart and Hutchings (cf. Journal American Society of Agronomy 28:714-722, 1936). In addition to furnishing a forage inventory and classifying erosion conditions of the watershed, this survey served as a means of coordinating the point-observation-plot and the reconnaissance method of survey.

ACCOMPLISHMENTS DURING THE PAST YEAR: The compilation and analysis of the Ephraim Canyon watershed survey data and the preparation of type maps were partially completed this past year.

PLANS FOR NEXT YEAR: The final compilation and summarization of these data and the preparation of type maps will be completed this year if funds and personnel are made available.

DATE OF COMPLETION: 1938.

ASSIGNMENT: Ira Clark.

RR - INT
Artificial Reseeding
Soils

March 15, 1938

THE QUALITY AND CONDITION OF RANGE SOILS

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Artificial Revegetation. (WORK PROJECT: Artificial Reseeding Investigations.)

SUBPROJECT: The quality and condition of range soils. (LINE PROJECT: The quality and condition of range soils.)

PURPOSE OF WORK: To determine the soil characteristics that are favorable or unfavorable to the establishment and production of available species of forage plants on depleted range lands requiring artificial revegetation.

REVIEW OF PAST WORK: General observations have indicated that although the various grasses differ widely in their specific requirements, deep soils of medium to fine texture and with a medium to high percentage of nitrogen and organic matter are most favorable for the production of grasses.

ACCOMPLISHMENTS DURING THE PAST YEAR: Detailed morphological profile studies of the representative soils of Ephraim Canyon have indicated the presence of most of the great soil groups. In passing from the warm, arid climate of the valley bottom to the high range lands of the Wasatch Range at an elevation of 5,000 feet or more above the valley, one passes through the various successional stages of soil development from the gray desert soils, through the brown and chernozem-like grassland soils to the podsol-like soils of the higher elevations under forest vegetation, and to the tundra-like soils at the highest elevations where the growing season is short and the soil is kept relatively moist and cold during a large portion of the year. A thorough understanding of the characteristics of these great soil zones and their relationships to forage production, as well as the specific conditions of a single site is essential to a range revegetation program. Some soils are admirably suited to a particular type of vegetation, whereas others are best utilized in the production of other forage or nonforage types.

The production of grass and other forage species has been increased materially as a result of applying a nitrogen fertilizer to badly depleted range soils. The effect of this treatment on the establishment of new grass seedlings in competition with weeds, which also respond quickly to the fertilizer, is not yet fully ascertained.

A large percentage of the range soils in this region has been found devoid of the nitrogen-fixing bacteria, either the free living type which live independently of any particular plant species, or the symbiotic forms which produce root nodules on leguminous plants. In view of the fact that nitrogen plays an important role in plant nutrition and is of particular importance in the production of forage, and also because of the generally low nitrogen content of most range soils in this region, it is significant that these micro-organisms are not active in the fixation of nitrogen in many of our range soils. The specific reasons for the absence of these bacteria are not apparent and are in need of investigation.

PLANS FOR NEXT YEAR: A study of the profile characteristics of representative range soils in the vicinity of the various work centers of the region will be continued with the viewpoint of establishing the soil characteristics that are favorable or unfavorable to the establishment and production of newly seeded species of forage plants. The fertilizer needs of these soils will also be studied by the application of fertizers, principally nitrogen and phosphorus carriers, to field plots and also to samples of the same soils maintained under ideal conditions in the greenhouse during the winter months. Physical, chemical, and biological studies will also be made of the various soils in the laboratory.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart, R. H. Walker, and A. C. Hull.

RR - INT
Artificial Reseeding
Surveys

March 15, 1938

ESTABLISHMENT OF THE LOCATION, EXTENT, AND DESCRIPTION OF RANGE AREAS REQUIRING ARTIFICIAL REVEGETATION.

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Artificial Revegetation. (WORK PROJECT: Artificial Reseeding Investigations.)

SUBPROJECT: Surveys. (LINE PROJECT: Surveys.)

PURPOSE OF WORK: To make an inventory of range sites and obtain information relative to the areas where artificial revegetation is needed or desirable as distinguished from areas that can be revegetated more economically and advantageously by proper management and control of livestock.

REVIEW OF PAST WORK: Specific inventories for the purpose of studying range sites from the standpoint of artificial revegetation have not yet been made in a systematic and thorough manner, although many observations of an empirical nature by various individuals have been made from time to time.

ACCOMPLISHMENTS DURING THE PAST YEAR: During the past year preliminary observations and studies have been made on the Wasatch and Manti National Forests in Utah and on the Humboldt National Forest in Nevada. Areas where detailed study is now required and where specific information will need to be obtained to further the artificial revegetation program have been located.

PLANS FOR NEXT YEAR: It is planned to proceed with the detailed inventory program in the vicinity of the Great Basin Branch Experiment Station on the Manti National Forest and also in the vicinity of the Clover Creek and the Lamance work centers in northern Nevada. A description of the areas will be made and will include (1) a map showing the location, boundaries, and general characteristics, (2) detailed information concerning the soil type with reference to its inherent morphological characteristics and present state of preservation of the surface soil, (3) general topography, slope, exposure and elevation, (4) ecological data concerning the characteristics of the remnant plant cover, and also of the native vegetation of surrounding areas, and (5) climatological data with reference particularly to the annual and seasonal distribution of precipitation, and length of the growing season.

DATE OF COMPLETION: This inventory will be made in unit sections so a unit may be completed each year. Several years will be required to complete the inventory for the entire region.

ASSIGNMENT: George Stewart, R. H. Walker, and A. C. Hull.

RR - INT
Artificial Reseeding
Species Adaptation

March 15, 1938

ADAPTATION OF PLANT SPECIES FOR USE IN ARTIFICIAL REVEGETATION

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Artificial Revegetation. (WORK PROJECT: Artificial Reseeding Investigations.)

SUBPROJECT: Species Adaptation. (LINE PROJECT: Species Adaptation.)

PURPOSE OF WORK: To determine the forage species, whether native, imported, or produced by plant breeding, that are best adapted to the different soil types and to various moisture, seasonal and altitudinal conditions.

REVIEW OF PAST WORK: In experiments conducted in Ephraim Canyon and on the Wasatch Plateau in central Utah, the wheatgrasses, particularly crested and western wheatgrasses, have grown well in the sagebrush zone at an elevation of 7,200 feet. Smooth brome also does well at this location but grows better in the aspen zone at a higher elevation. At 10,000 feet elevation smooth brome grows luxuriantly, but often fails to produce viable seed. Although mountain brome is adapted to somewhat the same general conditions as smooth brome, it grows best in the moister sites and also in partial shade. Slender wheatgrass has also produced well at the higher elevations. Only in wet meadows have Kentucky bluegrass and timothy done well.

ACCOMPLISHMENTS DURING THE PAST YEAR: Experiments to determine the adaptation of forage species have been initiated at 17 locations in this region. Sixty-seven species are being tested and seedings have been made on 1,696 experimental plots. Four plant nurseries have been established on typical range types where detailed studies of growth and adaptation can be made on promising species before they are subjected to range reseeding trials.

Crested wheatgrass has grown well in reseeding trials on the spring-fall ranges of northern Nevada, on the Snake River plains of southeastern Idaho, and also on abandoned dry-farms. Common brome and mountain brome have grown well on the high summer ranges of the Wasatch Mountains in central and northern Utah where depleted areas were reseeded. Other species that have shown considerable promise for reseeding on the high summer ranges are slender and crested wheatgrass, tall oatgrass, meadow fescue, and reed canary grass.

Indications are that bulbous bluegrass (Poa bulbosa) will in some areas crowd out and replace annual grasses of little value, such as downy chess (Bromus tectorum). It is a palatable, nutritious, perennial bunchgrass which grows in early spring and late fall but remains dormant during the summer; for this reason it is adapted to foothill ranges used for spring-fall grazing where the soil does not have sufficient moisture supplying capacity for better forage grasses.

PLANS FOR NEXT YEAR: Although a few new experiments will be initiated at the principal work centers, the main effort will be directed toward a continuation and detailed study of the experimental seedings now established. Determinations will be made of seedling survival, density of stand and forage yield. Work at the nurseries will be expanded to include studies on a large number of available species planted in rows, in broadcast plot seedings, and of individual plants started as transplants from greenhouse flats.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart, R. H. Walker, and A. C. Hull.

RR - INT
Artificial Reseeding
Methods of Revegetation March 15, 1938

METHODS OF RESEEDING AND OTHER PROPAGATION

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Artificial Revegetation. (WORK PROJECT: Artificial Reseeding Investigations.)

SUBPROJECT: Methods of revegetation. (LINE PROJECT: Methods of revegetation.)

PURPOSE OF WORK: To determine the most practicable time and methods of sowing or transplanting and subsequent treatment in order to bring about the revegetation of depleted ranges.

REVIEW OF PAST WORK: Artificial reseeding has given the best results when the seed has in some way been covered with soil after seeding. Several methods have been tried with varying degrees of success. Trampling with sheep, and going over the land with a brush drag or harrow have been shown to be effective for this purpose. Favorable results were also obtained from plowing furrows 3 feet apart and on the contour as a means of preparing the land for seeding. Brush dragging the land subsequent to seeding on areas so prepared proved successful.

Drilling seed with a grain drill without previous soil preparation has given some indication of success on abandoned farm land, and also on smooth, open range land where it is possible to use a grain drill.

Although fair success has been attained from spring sowings in reseeding trials on the foothill ranges, the indications are that fall is a better time to sow. Sufficient data are not yet available for specific indications as to the best time to sow on the high summer ranges, but even on these ranges it appears that fall sowing may prove to be most practicable.

ACCOMPLISHMENTS DURING THE PAST YEAR: Several experiments were started to further the work on this subproject. Drillings of a few of the most promising grass species were made on abandoned farm land or depleted range in cooperation with livestock men in Utah, Idaho and Nevada. Drilling trials were also made at the Arrowrock Substation, the Manti National Forest, the Dixie National Forest, the Desert Branch Experimental Station and the Shivwits Indian Reservation in southeastern Utah.

Other experiments were initiated to compare the efficiency of different methods of removal of native vegetation, soil preparation, different methods of sowing, and seed covering, rates, time and date of sowing. Inasmuch as these experiments were started during the past year they have not yet yielded data that will permit of the drawing of conclusions at this time.

PLANS FOR NEXT YEAR: Observations will be made on the experiments started during the past year, and new experiments, designed for the same purpose, will be initiated at the principal work centers.

DATE OF COMPLETION: All the experiments now started should be conducted over a period of at least 5 years and longer if possible. Others that will be started this year and in years to come should also be carried over a similar period of study.

ASSIGNMENT: George Stewart, R. H. Walker, and A. C. Hull.

RR - INT
Artificial Reseeding
Methods of Revegetation
RI - INT
Watershed Control
Erosion Control
Idaho

March 15, 1938

METHODS OF ARTIFICIAL REVEGETATION ON DEPLETED RANGE WATERSHEDS OF THE GRANITIC SOIL TYPE IN IDAHO

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Artificial Revegetation. (WORK PROJECT: Artificial Reseeding Investigations.)

SUBPROJECT: Methods of revegetation. (LINE PROJECT: Methods of revegetation.)

PURPOSE OF WORK: To demonstrate efficient and practical means of revegetating depleted range lands in southern Idaho.

REVIEW OF PAST WORK: Inspection, surveys, and plot studies, initiated in 1930 have indicated that on much of the severely depleted foothill lands in the Snake River drainage climatic and edaphic conditions are so unfavorable that artificial means of revegetation will have to be employed to provide satisfactory range cover within a reasonable time. Variety trials at Arrowrock substation have provided some information on which species are most adapted to the conditions in that area, and have shown the necessity of fully covering the seed in order that seedlings can establish themselves before the coarse soils become dry at the root zone. At other work centers, the construction of terrace trenches for erosion control purposes was found to improve soil moisture conditions enough to significantly increase the success of reseeding efforts, and this technique has been suggested for erosion control and revegetation purposes on the granitic soils of Idaho. Planting of cuttings of browse species has met with some success at Arrowrock substation and this method merits further trial.

The foregoing review indicates that although no one method of revegetation can be confidently recommended for application to the problem area, several methods have shown promise under certain conditions. The urgent need for action makes it advisable to conduct preliminary trials of the more promising methods on a large scale basis so that practical revegetation can be begun as soon as possible.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) An improved method of seeding has been perfected through the modification of a 1-horse grain drill by the addition of an agitator to facilitate feeding

and of outrider wheels to permit seeding on slopes steeper than 60 percent. (b) A 330-acre unit watershed near the Arrowrock substation has been selected and the most promising known methods of revegetation have been applied to it. Treatments include: (1) No treatment other than protection from grazing to permit natural recovery, 35 percent of the area. (2) Broadcasting of seven seed mixtures followed by harrowing, 4 percent of the area. (3) Drilling of seven seed mixtures by means of the specially modified drill in contour strips 10 feet (vertical distance) apart, 49 percent of the area. (4) Planting of cuttings of Rosa spp. and Rhus trilobata and of seedlings of Robinia pseudoacacia in contour strips 20 feet (vertical distance) apart, 8 percent of the area. (5) Terrace trenching followed by reseeding of promising species, 4 percent of the area. (This treatment planned but not yet effected.)

Since the unit area is quite typical of the entire problem area, the results, including the percent of area treated by each method, will apply directly to the problem. All treatments can be done at an economically feasible cost.

PLANS FOR NEXT YEAR: (a) Terrace trenching followed by reseeding will be tested (in cooperation with FI). (b) The success of the various treatments will be determined by recurrent checks. (c) The method will be extended to adjacent areas (in cooperation with the Boise N. F.)

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart and C. Kenneth Pearse.

RR - INT
Artificial Reseeding
Cost and Practicability

March 15, 1938

COST AND PRACTICABILITY OF ARTIFICIAL REVEGETATION

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Artificial Revegetation. (WORK PROJECT: Artificial Reseeding Investigations.)

SUBPROJECT: Cost and practicability of artificial revegetation. (LINE PROJECT: Cost and practicability of artificial revegetation.)

PURPOSE OF WORK: To determine the practicability and cost of the various promising features of artificial revegetation as they are developed in their technical phases under the other artificial revegetation subprojects.

REVIEW OF PAST WORK: Only estimates of cost and general observations concerning the practicability of reseeding depleted ranges on a large scale basis have been made in the past. Reseeding trials where these factors may be adequately evaluated are needed before reseeding can be considered practicable.

ACCOMPLISHMENTS DURING THE PAST YEAR: The entire watershed in Lime Canyon, north of Salt Lake City, has been seeded to promising species, but the test has not yet been in operation for a sufficient period to permit of the drawing of conclusions.

PLANS FOR NEXT YEAR: A new area of depleted spring-fall range and one of summer range will be seeded to promising species on a large scale or practical basis. Complete cost records will be kept. Studies of range improvement will be made in successive years, and eventually the areas will be grazed to determine the increased grazing capacity as a result of the reseeding.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart, R. H. Walker, and A. C. Hull.

RR - INT
Artificial Reseeding
Seeds

March 15, 1938

SEED STUDIES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Artificial Revegetation. (WORK PROJECT: Artificial Reseeding Investigations.)

SUBPROJECT: Seed Studies. (LINE PROJECT: Seed Studies.)

PURPOSE OF WORK: To determine the proper time, place, and methods of gathering, curing, and storing seeds of native forage species; to determine the ways and means for seed increase and production; and to determine the germination requirements and characteristics of the various grass and other desirable range forage species.

REVIEW OF PAST WORK: The viability of grass seeds is extremely variable; the divergence exists, not only between species, but also in the seed of individual species grown in different localities where the environmental conditions may have affected materially the complete development of the seeds. Furthermore, seeds have been found to differ appreciably in the length of time they will remain viable and also in the environmental conditions requisite for their germination.

ACCOMPLISHMENTS DURING THE PAST YEAR: Seed of native species not obtainable elsewhere namely, Agropyron spicatum, Agropyron inerme, Elymus condensatus, and Elymus glaucus were collected for reseeding experiments. Preliminary trials on various methods of collecting these species weremade, as well as on methods of harvesting, threshing, and cleaning of Agropyron cristatum seed produced under cultivation. A few native species have been sown on large plots of cultivated land to determine the practicability of seed production artificially. Germination studies are being conducted to determine the viability and germination characteristics and requirements of the several forage species employed in artificialreseeding experiments. All of these studies were initiated during the past year, hence no data are available as yet for the support of definite conclusions.

PLANS FOR NEXT YEAR: The experiments initiated this year will be continued; additional plantings of native species will be made for seed production; further studies will be made of germination characteristics of native species; and methods of seed collection and harvesting will be studied.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart, R. H. Walker, and A. C. Hull.

RR - INT
Artificial Reseeding
Plant Breeding

March 15, 1938

PLANT BREEDING - SELECTION AND HYBRIDIZATION

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Artificial Revegetation. (WORK PROJECT: Artificial Reseeding Investigations.)

SUBPROJECT: Plant breeding - selection and hybridization. (Conducted cooperatively with the Bureau of Plant Industry and the Utah State Agricultural Experiment Station, with the Bureau of Plant Industry acting as leader and prosecuting the detailed work of the subproject.) (LINE PROJECT: Plant breeding - selection and hybridization.)

PURPOSE OF WORK: To produce improved strains of range plants by selection; to determine the pollen production and quality, and pollination habits of range plants as a basis for hybridization; and to produce improved strains of range plants by hybridization.

REVIEW OF PAST WORK: During the calendar year 1936 a considerable collection of grasses had been obtained to serve as foundation stock for subsequent selection and hybridization studies. From 200 to 500 plants of the range forage species thought to be best adapted were set out one plant in a place. Great variation in forage yield, seed production, erectness, and leafiness showed up in most strains. The most promising of these were chosen for further study. Not much seed was produced the first season.

ACCOMPLISHMENTS DURING THE PAST YEAR: The individual plants of the various grass species developed well and in most cases seeded abundantly after natural pollination. A series of the most vigorous plants was bagged to produce self-pollinated seeds, some of them producing considerable seed this way and others seeding very sparsely. A small number of naturally pollinated plants that seemed to be good forage yielders and high seed producers was harvested separately to start progeny tests. A larger number of the high-yielding plants was harvested and the seed of the massed strains made available for plot tests.

PLANS FOR NEXT YEAR: The work will be continued on very much the same basis as it has been conducted during the past two years. As soon as desirable pure strains are available crossing will be attempted.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart, R. H. Walker, and A. C. Hull of the Forest Service, and Wesley Keller and Dean McAlister of the Bureau of Plant Industry.

RR - INT
Management

March 15, 1938

METHODS OF STUDYING VEGETATION ON INTERMOUNTAIN RANGES

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Experimental design and methodology. (WORK PROJECT: Summer range, sagebrush-grass and salt-desert shrub investigations.)

SUBPROJECT: Methodology. (LINE PROJECT: Methodology.)

PURPOSE OF WORK: To determine the most efficient methods of studying native range vegetation.

REVIEW OF PAST WORK: The study of adaptability of methods of studying native range vegetation to the Intermountain ranges was actively begun in 1932.

The adaptability of the point-observation-plot method of determining plant density and of the coordinate method of mapping low shrubs were designed, studied, and found to be suitable to the summer, sagebrush-grass, and salt-desert shrub range types. In conjunction with influence studies on granitic soils, an improved type of pantograph was designed and reported.

The stem-count method of determining range utilization reported by Stoddart in Ecology 16:531-533 was tested under range conditions and found to be too inaccurate for use in range studies on sagebrush-grass ranges.

Using Agropyron spicatum several methods of determining percentage utilization were studied and tested for accuracy. Definite recommendations concerning the methods arising from the results of the study indicate that ocular-estimate-by-plot methods in conjunction with actual checking of estimates provides a fairly reliable means of securing information concerning percentage utilization on sagebrush-wheatgrass ranges.

A study of existing methods of determining the amount of plant cover for use in grazing studies resulted in the design of the "weight-estimate" method. This method tested in conjunction with the "point-observation-plot" method revealed that for the type of material being studied "weight-estimates" were more sensitive to changes in herbage yield than density estimates by the "point-observation-plot" method. The method was tentatively recommended for use in pasture studies.

ACCOMPLISHMENTS DURING THE PAST YEAR: A preliminary study of the effect of usage of estimate methods embodying some personal error as contrasted to the usage of clipping methods was conducted on some data collected in connection with pasture inventories by the weight-estimate method. It was found that where the experimental material was as varied as that occurring on sagebrush-grass ranges, personal error in estimate methods was small as compared to the variability of the experimental material and that it was far more profitable from the standpoint of efficiency to sample adequately with estimate methods than to secure an inadequate sample by exact methods. Definite recommendations for the continuance of this investigation were prepared.

PLANS FOR NEXT YEAR: The study of methods of studying native range vegetation efficiently will be continued with special emphasis on character and extent of personal error in estimate methods.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart, Selar S. Hutchings, Ira Clark, and J. F. Pechanec.

RR - INT
Management

March 15, 1938

DESIGN OF EXPERIMENTS IN RANGE INVESTIGATION

FIELD DIVISION: Range Investigations.

FUNCTIONAL PROJECT: Experimental design and methodology. (WORK PROJECT: Summer range, sagebrush-grass, and salt-desert shrub investigations.)

SUBPROJECT: Experimental design. (LINE PROJECT: Experimental design.)

PURPOSE OF WORK: To investigate the nature of variation of experimental material being used, methods of sampling, and types of experimental design that may increase the efficiency of range experimentation.

REVIEW OF PAST WORK: This project was actively initiated in 1937.

ACCOMPLISHMENTS DURING THE PAST YEAR: A review of data available indicates that with present methods of experimentation the variation of native range vegetation is from three to more than seven times that encountered in agricultural field experimentation. Not only is the experimental material extremely variable, but frequency distributions of errors indicate that in range investigations frequencey distributions of native range species form strongly skewed or Poisson distributions. Since the customary tests of significance employed are based on normal distributions and are of doubtful validity when used for as skewed distributions as are inherent in range vegetation, present sampling methods or experimental design need be studied to determine methods of decreasing the skew to permit use of customary forms of statistical analysis.

Preliminary investigations of accuracy of sampling indicate that with the present type of sampling and intensity of cruise commonly used in pasture studies, only very crude treatment contrasts may be defined accurately.

Studies of the use of covariance as a means of improving the efficiency of experimental data definitely indicate that it may provide an excellent tool for eliminating much of the heterogeneity of the experimental material and by so doing increase the precision of the experiment materially. A report on the use of covariance analysis in range research has been prepared for publication.

PLANS FOR NEXT YEAR: Studies of sampling of range vegetation and of more efficient experimental design will be definitely inaugurated in 1938.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: George Stewart, Selar S. Hutchings, Ira Clark and J. F. Pechanec.

R - INT
Investigative Program
1937

March 15, 1938

PREFACE TO INFLUENCE PROJECT STATUS SHEETS

The influence research program at the Intermountain Station has as its major objective the development of watershed management practices which will lead to maximum yields of usable streamflow, the prevention of accelerated erosion, and the reduction of flood hazards. To reach this objective, research is being conducted on four functional aspects of watershed management as follows:

1. Watershed Factors, including studies of the run-off and erosion potential of watershed lands and how these phenomena are influenced by the operation of such factors as (a) climate and weather, (b) topography, (c) soil, (d) plant cover, and (e) streamflow.

2. Watershed Utilization, including studies aimed at determining the extent to which range watersheds may be grazed without adversely affecting their normal watershed functions.

3. Watershed Control, including studies aimed at improving watershed conditions through the development of suitable measures for (a) preventing erosion, (b) controlling floods, and (c) conserving streamflow.

4. Watershed Surveys, including flood control surveys aimed at determining the character of and economic need for watershed improvement measures.

As indicated in the following project status sheets, intensive studies concerning the first three functional aspects of watershed management listed above are being conducted on the western slopes of the Wasatch Mountains and the Wasatch Plateau of the Great Basin in Utah, and on the granitic soil-bunchgrass range of the Boise River watershed in Idaho, while flood control surveys are under way in the Green and Snake River watersheds.

RI - INT
Watershed Factors
Climate
Great Basin

March 15, 1938

GREAT BASIN CLIMATIC STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Factors. (WORK PROJECT: Great Basin.)

SUBPROJECT: Climatic factor. (LINE PROJECT: Climatic factor.)

PURPOSE OF WORK: To determine the climatic factor on range watersheds of the Great Basin and their relationship to stream flow, surface run-off, and erosion.

REVIEW OF PAST WORK: The climatic characteristics of high mountain range watersheds of the Great Basin are known to determine to a very marked extent the availability of water as stream flow for agricultural, industrial, and culinary purposes in the adjacent semidesert valleys. Devastating floods following torrential storms have been attributed to rapid surface run-off from mountainous lands depleted of plant cover. On the Davis County watershed in Utah, definite steps were taken in 1934 to study the climate, principally precipitation of the area, because of the need for knowing its influence on seasonal distribution of stream flow, floods, mud-rock flows and accelerated erosion. Climatic studies now constitute one of the major phases of work at the Wasatch Branch Station where facilities for gathering data consist of 86 standard rain gages arranged by elevational zones and aspects, tied into two physical factor stations equipped with intensity rain gages and thermographs. Two snow courses and 36 snow sampling sites are also in use on the area.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) Rainfall intensities as high as 0.95 inch in 15 minutes have been recorded on the Davis County, Utah watershed. This storm resulted in flood producing run-off from plots with annual weed cover and indicates the severity of the precipitation factor along the Wasatch front. (b) Approximately 1 inch of rainfall over a one-half hour period produced spectacular mud-rock flows from watersheds of less than 100 acres, of which about 20 percent contributed serious run-off, indicating further the importance of the precipitation hazard on mountainous watersheds typical of the Wasatch front. (c) A year-long precipitation station has been installed at 6,700 feet elevation on the Wasatch Experimental watersheds.

PLANS FOR NEXT YEAR: (a) Continue operation of present installations. (b) Develop cheap and reliable rain and snow gages suitable for winter-long operation with little or no attention. (c) Increase number of standard gages so as to give complete and adequate coverage of the areas now being studied.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: A. R. Croft.

RI - INT
Watershed Factors
Climate
Idaho

March 15, 1938

IDAHO CLIMATIC STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Factors. (WORK PROJECT: Bunchgrass-granitic soil, Idaho.)
SUBPROJECT: Climatic Factors. (LINE PROJECT: Climatic Factors.)

PURPOSE OF WORK: To evaluate the influence of climatic factors within the bunchgrass-granitic soils range lands of south Idaho as related to run-off and erosion.

REVIEW OF PAST WORK: Analyses of available records have substantiated the generally accepted premise that climate, more especially precipitation and temperature, is a direct and important factor in the quantity and quality of stream flow on the Boise River watershed. Similar analyses together with carefully controlled tests have also shown that intense summer storms are the final causative agent of abnormal run-off and accelerated erosion, and that drought and other vicissitudes of climate are powerful indirect causes of these phenomena through their influence upon the stability of a protective plant cover. The establishment of an extensive system of cooperative weather stations over the Boise River watershed since the initiation of intensive erosion studies in 1929 has been of material aid in developing a sound basis for determining the climatological characteristics of this problem area.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) Precipitation deficiencies in May 1937 prevented the successful establishment of artificial grass seedings as an erosion control measure on the foothill range lands clearly suggesting that this hazard be considered in future revegetation efforts. (b) Preliminary trials indicate a newly developed combination snow board-rain gage will be satisfactory for obtaining accurate records of winter precipitation on areas which are subject to drifting and recurrent snow melting. (c) A start was made on the development of a precipitation gage that will operate all winter without attention.

PLANS FOR NEXT YEAR: (a) Continue climatological records, and (b) complete development of satisfactory winter precipitation gages.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: C. Kenneth Pearse.

RI - INT
Watershed Factors
Topography
Great Basin

March 15, 1938

GREAT BASIN TOPOGRAPHIC STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Factors. (WORK PROJECT: Great Basin.)

SUBPROJECT: Topography. (LINE PROJECT: Topography.)

PURPOSE OF WORK: To determine for the Great Basin the influence of topography on stream flow, surface run-off, and accelerated soil erosion.

REVIEW OF PAST WORK: Surveys made since 1930 on many watersheds within the Great Basin show that soil, ages in the making, is being lost by accelerated erosion. Greatest losses appear to be occurring on south aspects and in many instances on slopes steeper than the normal angle of repose of the soil material and which have been developed under the protective influence of a plant cover. Other studies have indicated the headwater lands above 7,000 feet in elevation to be the major source of stream flow, while observations have suggested that north and south aspects are significantly different with respect to their influence on total and seasonal yield of stream flow. Sixteen surface run-off plots were installed in 1935 to measure the influence of slope on run-off and erosion. In 1937, instruments were installed for studying soil formation processes on north and south aspects. In the same year, 10 gaging stations were installed to measure the influence of aspect and altitude on water yield.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) A 44 percent slope with plant cover density equalling 8 percent yielded no more run-off and eroded material than a 22 percent slope with plant cover density of 4 percent, the advantage of the more gradual slope being offset, presumably by the additional 4 percent plant cover on the steeper slopes. (b) During 1937 a south aspect watershed yielded more summer flow than a north aspect area, but the extent to which this relationship prevails in the region requires further study. (c) Large quantities of snow are blown from south and west facing slopes into deep drifts on the north and east aspects.

PLANS FOR NEXT YEAR: Continue (a) run-off and erosion plot installations, (b) aspect stream flow study, (c) elevation stream flow study, and (d) aspect soil formation study.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: A. R. Croft.

RI - INT
Watershed Factors
Topography
Idaho

March 15, 1938

IDAHO TOPOGRAPHIC STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed factors. (WORK PROJECT: Bunchgrass-granitic soils, Idaho.)
SUBPROJECT: Topography. (LINE PROJECT: Topography.)

PURPOSE OF WORK: To evaluate the influence of topography on run-off and erosion in the bunchgrass-granitic soil type of south Idaho range lands.

REVIEW OF PAST WORK: Surveys on the Boise River watershed in 1929 and 1930 indicated that erosion varied directly with degree of slope up to 35 percent but that on steeper slopes the specific influence of slope was obscured by the interaction of such other contributing factors as soil disturbance, plant cover, grazing, and rodents. Subsequent studies with portable apparatus revealed run-off and erosion to be significantly greater on 40 percent than on 30 percent slopes and that the effect of slope steepness was most pronounced on depleted range, especially under conditions of disturbed soils. Because of the extent of depleted, eroding range lands, studies in 1937 were aimed at determining the effect of a wide range of slopes on run-off and erosion within this type as a basis for planning watershed control measures.

ACCOMPLISHMENTS DURING THE PAST YEAR: Measurements with portable apparatus on 20, 30, 40, 50, and 60 percent slopes within the annual weed type revealed that slope *per se* had no significant influence on run-off, apparently due to inherent differences in soil characteristics within this range of slope steepness. On the other hand, erosion increased with increase in slope, being about six times greater on 60 than on 20 percent slopes. These results clearly show the high erosion potential of steep slopes in this type of range and definitely indicate that these lands should receive first consideration in erosion control efforts.

PLANS FOR NEXT YEAR: (a) Extend measurements of the run-off and erosion potential of varying slopes to other important range types. (b) Supplement the run-off and erosion measurements with soil studies to isolate and evaluate the factors contributing to infiltration on varying slopes.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: C. Kenneth Pearse.

RI - INT
Watershed Factors
Soil
Great Basin

March 15, 1938.

GREAT BASIN SOIL STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Factors. (WORK PROJECT: Great Basin Erosion.)

SUBPROJECT: Soil. (LINE PROJECT: Soil.)

PURPOSE OF WORK: To determine (a) the influence of certain soil characteristics on infiltration and accelerated erosion on range-watersheds of the Great Basin, and (b) the extent and nature of soil losses resulting from accelerated erosion.

REVIEW OF PAST WORK: Surveys conducted in 1934, 1935, and 1936 indicated that both altitude and aspect influence the organic matter content of soils, those at high altitude or on north aspects having deeper organic horizons than those at lower elevations or south aspects, and that infiltration and erosion potentials definitely vary with altitude and aspect. In connection with these surveys, studies were initiated to develop both field and laboratory criteria to be used in determining the specific influence of the soil factor in the water cycle.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) A method was developed for determining soil losses from accelerated erosion in the mountain brush zone. This method is based on a comparison of indices determined qualitatively by ocular examination of soils in the field to those determined quantitatively in the laboratory. (b) Heavy accelerated erosion reduced organic matter as much as 70 percent, total nitrogen 39 percent, and moisture equivalent 67 percent. (c) In the Wasatch Mountains accelerated erosion appears to be more readily induced and more extensive on south facing slopes than on north facing slopes.

PLANS FOR NEXT YEAR: (a) Continue accelerated erosion criteria studies in Canadian and subalpine life zones. (b) Make soil inventory of 800 acres of experimental watersheds.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: A. R. Croft.

RI - INT
Watershed Factors
Soil
Idaho

-March 15, 1938

IDAHO SOIL STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed factors. (WORK PROJECT: Bunchgrass-granitic soil, Idaho.)

SUBPROJECT: Soil. (LINE PROJECT: Soil.)

PURPOSE OF WORK: To evaluate the influence of edaphic factors or run-off and erosion within the bunchgrass-granitic soil range lands of south Idaho.

REVIEW OF PAST WORK: A range erosion survey on the Boise River watershed in 1929 showed that such readily discernible soil characteristics as color, texture, and litter cover were closely associated with the degree of erosion. These observations suggested the need for more critical studies of the influence of measurable soil properties on infiltration rates as a basis for understanding the function of the soil mantle in the water cycle.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) In studies of infiltration rates on bare soils, the presence of organic matter in the surface soil was found to be four times more effective than soil texture and five times more effective than soil moisture content in inducing percolation of surface water. Considering the coarse texture of the granitic soil involved, the influence of the presence of organic matter is especially significant and clearly demonstrates the need for maintaining humic material in the soil as an aid in reducing surface run-off and erosion. (b) In comparable tests along a fence line, the infiltration rate of soil that had been protected from trampling for four years was three times greater than on previously comparable soil but which during the past four years has been subject to trampling and current erosion.

PLANS FOR NEXT YEAR: (a) Make correlation analyses of infiltration rates with run-off rates and soil properties to determine the value of infiltration measurements and of critical soil analyses as a basis for studying the more complex phenomenon of surface run-off. (b) Develop useful criteria for recognizing accelerated erosion in early stages.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: C. Kenneth Pearse.

RI - INT
Watershed Factors
Plant Cover
Great Basin

March 15, 1938

GREAT BASIN PLANT COVER STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Factors. (WORK PROJECT: Great Basin.)

SUBPROJECT: Plant Cover. (LINE PROJECT: Plant Cover.)

PURPOSE OF WORK: To evaluate the influence of plant cover on surface run-off, accelerated erosion, and stream flow within the Great Basin watersheds.

REVIEW OF PAST WORK: Surveys in 1930 covering 25 Utah watersheds from which recent floods had occurred showed that in 15 cases depleted condition of plant cover was the major cause giving rise to flood run-off; that in 7 cases paucity of plant cover (conditioned by natural physiographic factors unfavorable to plant growth) played an important part; and that in only 3 cases were natural physiographic features considered the principal factor. Other surveys made principally in Davis County between Salt Lake City and Ogden, on watersheds of the west front of the Wasatch Mountains showed that 15 out of 16 contiguous drainages produced serious floods in 1930. The lone exception was a drainage on which plant cover had been well preserved through municipal ownership and management. As a means of further testing the influence of plant cover twelve 1/40-acre plots and four 1/10-acre plots were established in three cover types on the Davis County watershed.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) A herbaceous plant cover of 14.5 percent density with comparatively deep litter from an overstory of open aspen growth was found to be 75 times as effective in controlling surface run-off as a 4 percent cover of annual weeds, and 52 times as effective as an 8 percent cover of browse. (b) The aspen plots lost no soil, but the annual weed type and the browse type plots eroded at the rate of 457.6 $ft.^3$ and 376.0 $ft.^3$ per acre respectively.

PLANS FOR NEXT YEAR: Continue operation of all installations.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: A. R. Croft.

RI - INT
Watershed Factors
Plant Cover
Idaho

March 15, 1938

IDAHO PLANT COVER STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed factors. (WORK PROJECT: Bunchgrass-granitic soil, Idaho.)
SUBPROJECT: Plant cover. (LINE PROJECT: Plant cover.)

PURPOSE OF WORK: To evaluate the influence of plant cover on run-off and erosion within the bunchgrass-granitic soil range lands of south Idaho.

REVIEW OF PAST WORK: A range-erosion survey on the Boise River watershed in 1929 showed plant cover to be more closely related to accelerated erosion than any of seven observed factors except soil condition and use by livestock. In 1935 and 1936, more detailed plot studies revealed that plant type is much more important than rainfall intensity, gradient or soil disturbance in controlling surface run-off and erosion, thus clearly indicating the importance of plant cover as an element in the run-off and erosion problem. These and related infiltration and root studies further indicated that the perennial bunchgrass cover is much more effective than other plant cover on depleted range for controlling run-off and erosion, its efficiency being due in part, at least, to the more extensive and fibrous root systems. Studies are now being directed at determining, by means of lysimeter studies, the relative cost in terms of water losses of watershed protection by these plant types. A battery of six 2-milacre steel lysimeters was installed at Bannock Creek Substation in 1932 for this purpose.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) Four-foot profiles of homogeneous bare granitic soil have been found to retain (and evaporate) about 60 percent of the annual precipitation; practically all of the net yield occurs as seepage during and immediately after snow melt. (b) During the past season two of the lysimeters were revegetated by transplanting to perennial grasses and related climax plants, two to subclimax species, and two were left in an annual weed stage.

PLANS FOR NEXT YEAR: Maintain lysimeter battery in operation.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: C. Kenneth Pearse.

RI - INT
Watershed Factors
Stream flow
Great Basin

March 15, 1938

GREAT BASIN STREAM FLOW STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Factors. (WORK PROJECT: Great Basin.)

SUBPROJECT: Stream flow. (LINE PROJECT: Stream flow.)

PURPOSE OF WORK: To determine stream flow characteristics from steep mountainous watersheds and to develop adequate devices for water measurement in the steep channels characteristic of the region.

REVIEW OF PAST WORK: An analysis of stream flow records from streams flowing into the Great Basin shows a wide range of seasonal variability. On some watersheds this variability may be decreased, and more uniform flow secured by artificial storage, but where watersheds are short and steep as is often the case in the Great Basin this cannot be done. Because huge investments in adjacent valleys are definitely dependent on stream flow for mountainous watershed lands, it is essential to know the maximum, minimum, and average flow over long periods as a basis for economic water use planning. It is also essential that stream flow characteristics be correlated with climate and with the variety of conditions that may grow out of the use of watersheds by man. In order that the wide fluctuations in flow may be accurately gaged in steep channels where measurements must be made a suitable measuring device has been developed under laboratory and field conditions. It is known as a Venturi-trapezoidal flume.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) Seventeen Venturi-trapezoidal flumes are now in operation at the Wasatch Branch Experiment Station on a year-long basis. (b) Observation of these flumes during 2 years of operation indicate that they are operating satisfactorily under the extremely low flow conditions of late summer as well as during flash flow of heavily silt-laden water. (c) Records from a typical watershed in the Wasatch Mountains in northern Utah, show that about 71 percent of the total yearly flow is produced during spring run-off in April, May, and June, and only about 9.5 percent during July, August, and September when the demand for water is most acute.

PLANS FOR NEXT YEAR: Continue studies of stream flow characteristics on short, steep watersheds of the Great Basin.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: A. R. Croft.

RI - INT
Watershed Utilization
Grazing
Great Basin

March 15, 1938

GREAT BASIN GRAZING STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Utilization. (WORK PROJECT: Great Basin.)

SUBPROJECT: Grazing. (LINE PROJECT: Grazing.)

PURPOSE OF WORK: To determine on lands within the Great Basin the extent grazing may be permitted without adversely affecting soil erosion, surface run-off, or seasonal distribution of stream flow.

REVIEW OF PAST WORK: Surveys made since 1929 on about 50 Great Basin watersheds or localities where serious floods have occurred, show that reduced plant cover and soil disturbance resulting from overgrazing is in the majority of cases the most important single factor contributing to flood run-off during torrential storms. To substantiate these studies and observations, treatment on Areas A and B near Ephraim, Utah is now being reversed. In addition, the basis for determining the maximum allowable utilization of various types of range-watershed lands is being furnished by records from two batteries of three 1/10-acre range utilization run-off plots which have been installed on the oak-sage and on the mixed brush and weed ranges at the Great Basin Branch Station. Six watersheds of about 125 acres each at the Wasatch Branch Station have been equipped with stream gaging stations and related instrumentation to determine the influence of degree of utilization on the character and seasonal distribution of stream flow from mixed-type steep range lands.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) As a result of changing the plant cover on Area B from 40 to 32 percent density, in the meantime holding that on A constant at 40 percent, ratios of A-B run-off and soil erosion changed from 2.27 to 1.12 and from 2.50 to 1.12 respectively. These plant density changes represent the first stages of a reversal of treatment on the two areas.

PLANS FOR NEXT YEAR: Continue studies on the A-B watersheds and the six 1/10-acre plots at the Great Basin Branch and on the six experimental watersheds at the Wasatch Branch.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: A. R. Croft.

RI - INT
Watershed Utilization
Grazing
Idaho

March 15, 1938

IDAHO GRAZING STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed utilization. (WORK PROJECT: Bunchgrass-granitic soil, Idaho.)

SUBPROJECT: Grazing. (LINE PROJECT: Grazing.)

PURPOSE OF WORK: To determine the extent grazing can be permitted on the bunchgrass-granitic soil range lands of south Idaho without adversely affecting run-off and erosion relationships.

REVIEW OF PAST WORK: Early range inspections and a detailed survey in 1929 revealed that overgrazing with concomitant destruction of the perennial herbaceous plant cover and disturbance of the loose granitic soil is an important factor contributing to a serious erosion problem on the Boise River watershed. Subsequent studies have shown that the most desirable range plants are also the most efficient for controlling run-off and erosion, thus indicating that revegetation of the original, perennial bunchgrasses and related plants is of two-fold importance. Drastic reductions in the number of permitted livestock have been made as a rehabilitation measure but the problem of determining the extent to which grazing is compatible with the watershed function of these lands remains to be solved. In 1935 two 10-acre watersheds were fenced and equipped with run-off measuring devices to determine the influence of plant cover and grazing on run-off and erosion, and in 1936 three range watersheds of about 200 acres each were developed for similar purposes on a more practical range utilization basis.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) Three years of record indicate the A-B watersheds to have a low surface run-off and erosion potential under conditions of complete protection, even when subjected to high intensity summer storms. (b) Stream gaging stations have been completed on the Wood Creek triplicate watersheds and daily records on a yearlong basis initiated.

PLANS FOR NEXT YEAR: (a) Continue operation of the A-B and triplicate watershed installations; (b) prepare detailed map and plant and soil inventories of triplicate watersheds, construct triplicate watershed debris basins, and acquire title to land.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: C. Kenneth Pearse.

RI - INT
Watershed Control
Erosion Control
Great Basin

March 15, 1938

GREAT BASIN EROSION CONTROL STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Control. (WORK PROJECT: Great Basin.)

SUBPROJECT: Erosion Control. (LINE PROJECT: Erosion Control.)

PURPOSE OF WORK: To develop methods of controlling accelerated soil erosion on the watershed lands of the Great Basin.

REVIEW OF PAST WORK: Studies made on watersheds principally along the high and steep west front of the Wasatch Mountains show that accelerated soil erosion is most serious on those areas where vegetation has been reduced to the annual weed stage. Loss of perennial vegetation has introduced such drastic changes in the micro-climate that natural rehabilitation of a soil stabilizing plant cover is greatly retarded. On depleted lands at the Wasatch Branch Station construction of contour trenches is solving the problem of holding soil in place through retardation of surface run-off. Moreover, the collection of run-off in trenches increases the moisture content of the soil, thereby enhancing restoration of a protective plant cover by both artificial and natural methods.

Serious erosion is also widespread on the low foothill lands of this region. To meet this phase of the problem the effectiveness of natural and artificial revegetation is being tested on twenty-four 1/200-acre plots. Tests were also initiated last year to determine the minimum standards for contour trenching on foothill lands.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) About 125 miles of contour trenches constructed on about 600 acres of rapidly eroding high and steep watershed land have checked accelerated soil erosion. (b) Recovery of perennial herbaceous vegetation has been rapid due to the influence of increased soil moisture from catchment of surface run-off water in trenches. (c) Tests with portable rain-making apparatus show that on low foothill lands where heavy snow accumulation is not a problem, a small cheaply constructed trench is suitable for erosion control purposes.

PLANS FOR NEXT YEAR: (a) Studies on the effectiveness of direct and indirect erosion control by contour trenches will be continued. (b) The relation of plant growth to seasonal soil moisture as influenced by trenches will be studied.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: A. R. Croft.

RI - INT
Watershed Control
Erosion Control
Idaho

March 15, 1938

IDAHO EROSION CONTROL STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed control. (WORK PROJECT: Bunchgrass-granitic soils, Idaho.)
SUBPROJECT: Erosion Control. (LINE PROJECT: Erosion control.)

PURPOSE OF WORK: To develop methods for controlling erosion on the depleted bunchgrass-granitic soil range lands of southern Idaho.

REVIEW OF PAST WORK: In 1929, surveys revealed serious accelerated erosion to be widespread on the range portion of the Boise River watershed and that its occurrence was closely associated with depletion of the original bunchgrass cover by overgrazing. Intensive studies initiated in 1930 showed the present annual type of cover to be greatly inferior for controlling run-off and erosion than the original cover, thus clearly suggesting revegetation to bunchgrass as a desirable erosion control measure. Plant successional studies, however, have revealed natural revegetation to be a very slow and uncertain process. Therefore, during the past 2 years emphasis has been placed upon studies aimed at hastening revegetation by artificial reseeding and mechanical control works. The Arrowrock substation was established on the Boise Forest in 1936 as headquarters for this and related work.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) The first phase of artificial reseeding trials show that seed drilling is more effective in establishing artificial grass stands than broadcast sowing. (b) A modified 1-horse drill has been perfected for contour strip seeding on slopes as steep as 70 percent. This method costs about one-fourth that of broadcast seeding on a complete coverage basis. (c) A substandard trench costing about one-third the standard trench has been found to be satisfactory for contour trenching on the coarse, granitic soils. (d) An erosion-control demonstration area has been established in cooperation with the Boise Forest to determine the practicability of all promising erosion control methods as a basis for initiating a much needed, large scale erosion control program. (e) Accumulated research data have been useful in furthering the Arrowrock purchase program.

PLANS FOR NEXT YEAR: (a) Continue demonstration area studies; (b) initiate road cut and fill stabilization studies; (c) test effectiveness of artificially reseeded plots for controlling run-off and erosion providing grasses become established; and (d) test effectiveness of shrubs for erosion control.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: C. Kenneth Pearse.

RI - INT
Watershed Control
Floods
Great Basin

March 15, 1938

GREAT BASIN FLOOD CONTROL STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Control. (WORK PROJECT: Great Basin.)

SUBPROJECT: Floods. (LINE PROJECT: Floods.)

PURPOSE OF WORK: To develop various methods, including use of engineering structures, suitable for effective control of floods in high mountainous watersheds of the Great Basin.

REVIEW OF PAST WORK: Surveys since 1923 have indicated that floods from Great Basin watersheds are increasing in severity and frequency. Floods have been widespread but the valley communities adjacent to the Wasatch Mountain front in northern Utah have suffered the heaviest damage. Damage in Davis County alone was more than $1,000,000 and through northern Utah probably twice that amount.

Since 1933 the following methods of flood control have been tried out in the Great Basin: (a) contour trenches sufficiently large to retain 75 percent of run-off from intense 2-inch rainfall; (b) diversion ditches; (c) gully and stream channel check dams; (d) small upstream debris basins; and (e) large debris basins at canyon mouths. In addition, complete protection of areas in various stages of plant depletion is being observed.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) Where run-off from areas even as small as 1 or 2 acres accumulates rapidly, such structures as diversion ditches, check dams, and to a lesser extent, small upstream debris basins, do not provide effective flood control. (b) Large downstream debris basins are usually incapacitated or destroyed by major floods. (c) Contour trenches have provided complete flood control, shown by comparisons of the effects of storms on trenched and untreated areas, storms of comparable intensity and duration producing floods and mud-rock flows on the latter.

PLANS FOR NEXT YEAR: (a) Continue studies of the effectiveness for flood control of all structures used to date, and (b) refine and develop measures for widespread use in combating floods elsewhere in the region.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: A. R. Croft.

RI - INT
Watershed Control
Water Conservation
Great Basin

March 15, 1938

GREAT BASIN WATER CONSERVATION STUDIES

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Control. (WORK PROJECT: Great Basin.)

SUBPROJECT: Water Conservation. (LINE PROJECT: Water Conservation.)

PURPOSE OF WORK: To determine measures that will increase the proportion of usable stream flow from mountainous watersheds.

REVIEW OF PAST WORK: Preliminary studies of small watersheds having no artificial storage facilities, show that from 65 to 90 percent of the total water yield is during spring run-off when demand for water is low. Several measures for conserving stream flow have been suggested. These include (a) spreading water on alluvial fans and deltas at canyon mouths for storage underground, (b) spreading water on the watershed in trenches as a means of delaying discharge, and (c) controlling riparian vegetation to eliminate excessive transpiration losses. So far, studies of water conservation at this station have been confined to waterspreading at the mouth of Centerville Creek. 1/

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) During January 1938 about 3,000 square feet of spreading area constructed in loose gravel absorbed 38 acre-feet of water. This is equivalent to about 550 cu. ft. of water absorbed per square foot of area exposed per month.

PLANS FOR NEXT YEAR: (a) Continue waterspreading study at Centerville, Utah. (b) Commence waterspreading studies at other promising localities. (c) Initiate studies of the influence of contour trenching on stream flow regulation.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: A. R. Croft.

1/ This study is being made in cooperation with the U.S.B.A.E. and Utah Agricultural Experiment Station as cooperators.

RI- INT
Watershed Surveys
Flood Control Surveys
Green River

March 15, 1938

GREEN RIVER FLOOD CONTROL SURVEY

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Surveys. (WORK PROJECT: Flood Control Surveys.)

SUBPROJECT: Green River Flood Control. (LINE PROJECT: Green River.)

PURPOSE OF WORK: To make preliminary examination and report concerning run-off and waterflow retardation and soil erosion prevention on the watershed of the Green River and its tributaries in Wyoming.

REVIEW OF PAST WORK: A new project.

ACCOMPLISHMENTS DURING THE PAST YEAR: Field work completed and report in process of preparation.

PLANS FOR NEXT YEAR: None.

DATE OF COMPLETION: June 30, 1938.

ASSIGNMENT: Reed W. Bailey and G. W. Craddock in cooperation with U. S. Bureau of Agricultural Economics and Soil Conservation Service.

RI - INT
Watershed Surveys
Flood Control Surveys
Snake River

March 15, 1938

SNAKE RIVER FLOOD CONTROL SURVEY

FIELD DIVISION: Influences.

FUNCTIONAL PROJECT: Watershed Surveys. (WORK PROJECT: Flood Control Surveys.)

SUBPROJECT: Snake River Flood Control. (LINE PROJECT: Snake River.)

PURPOSE OF WORK: To make preliminary examination and report concerning run-off and waterflow retardation and soil erosion prevention on the watershed of the Snake River and its tributaries (a) in Wyoming, and (b) in Idaho, Oregon and Washington.

REVIEW OF PAST WORK: A new project.

ACCOMPLISHMENTS DURING THE PAST YEAR: Field work on tributaries in Wyoming completed and report in process of preparation.

PLANS FOR NEXT YEAR: Complete field work and report upon tributaries in Idaho, Oregon, and Washington.

DATE OF COMPLETION: 1938.

ASSIGNMENT: Reed W. Bailey and G. W. Craddock in cooperation with U. S. Bureau of Agricultural Economics and Soil Conservation Service.

R - INT
Investigative Program
1937

March 15, 1938

PREFACE TO FOREST MANAGEMENT PROJECT STATUS SHEETS

The forest management investigations now being conducted by the Intermountain Station fall into four main categories designated as functional projects. To date studies have been confined almost entirely to the ponderosa pine type. Broadly speaking, the purpose of these investigations is to determine the best methods of managing ponderosa pine forests so as not only to realize the maximum growth and highest quality in the products of both uncut and reserve stands and to insure regeneration, but also to restore or to maintain yields of usable water at high levels and to perpetuate the lumber industry on a sound sustained economic basis.

To accomplish these objectives the investigative program has been predicated on four closely related, yet distinct, functional lines of activity which are:

1. Silviculture, including studies on (a) silvicultural and economic methods of harvest cuttings, (b) stand improvement measures to increase growth and quality, (c) natural regeneration of timber stands, and (d) phenology of forest trees and important associated vegetation.

2. Artificial regeneration, including studies on (a) seed collection, storage, and testing, (b) nursery culture, (c) field planting of nursery stock, and (d) artificial seeding.

3. Mensuration, including studies on (a) form, volume, and growth of individual trees, and (b) composition, growth, yield, and mortality of stands.

4. Fire protection, including studies on (a) fire behavior and control (principally fire danger prediction), and (b) effects of fires (principally damage).

RS - INT
M-1

March 15, 1938

METHODS OF CUTTING PONDEROSA PINE

FIELD DIVISION: Forest Management.

FUNCTIONAL PROJECT: Silviculture. (WORK PROJECT: Silvicultural Investigations.)

SUBPROJECT: Methods of Cutting. (LINE PROJECT: Methods of Cutting.)

PURPOSE OF WORK: To determine the most satisfactory methods of cutting pine to insure reserve stands yielding maximum growth and quality products, to insure satisfactory regeneration and to provide for maximum yields of usable water and sustained production of lumber and other products.

REVIEW OF PAST WORK: (1) The principal line of work has been the measurement of actual results of various methods of cutting on permanent sample plots established for this purpose. Growth, mortality, and reproduction on three such plots on the Payette and one on the Salmon National Forest have been reported from time to time (last report, 1934; last remeasurement, 1936). Seven plots established in 1933 on the Pine Creek Division of the Boise Basin Experimental Forest have to date yielded information on the exact nature of changes in stand structure resulting from various marking methods, wood waste under current standards of utilization, logging damage and early mortality in the reserve stand, and subsequent reproduction. (2) An extensive survey of five selectively cut areas in central Idaho in 1932-34 has shown on a broader basis the results in terms of growth, etc. of past Forest Service cuttings and has given data useful in planning future cuttings and in guiding more intensive methods-of-cutting studies. (3) About 3,300 acres of the Boise Basin Experimental Forest was set aside in 1933 to serve as a small demonstration unit of sustained yield operation and a testing area for various cutting methods and logging practices. A few utilization roads have been constructed but initiation of actual cutting is still awaiting certain economic developments.

ACCOMPLISHMENTS DURING THE PAST YEAR: A report on logging damage and other losses associated with selective cutting on the Pine Creek plots was completed. Caterpillar logging destroyed 40 percent of the seedlings and saplings, and burning of piled slash caused an additional loss of 17 percent. Of the reserve trees 4 inches in diameter and larger, logging destroyed 10 percent; slash burning 5 percent; and bark beetles 4 percent. Because of the difficulty of obtaining subsequent reproduction,

these losses are a threat to the production of full time crops. They could be materially reduced by greater care.

PLANS FOR NEXT YEAR: (1) Pine Creek plots will be remeasured. (2) The report on the extensive cut-over study will be completed. (3) Plans for a cutting operation on the experimental forest will be carried forward as far as cir-stances permit.

DATE OF COMPLETION: Cut-over study will be closed with completion of report (1938). Other phases will continue indefinitely.

ASSIGNMENT: T. E. Maki and E. L. Mowat.

RS - INT
Mt (&Mp)

March 15, 1938

PONDEROSA PINE STAND IMPROVEMENT

FIELD DIVISION: Forest Management.

FUNCTIONAL PROJECT: Silviculture. (WORK PROJECT: Silvicultural Investigations.)

SUBPROJECT: Stand Improvement. (LINE PROJECT: Stand Improvement.)

PURPOSE OF WORK: To evolve and put into practice methods of stand improvement which are silviculturally and economically feasible in the ponderosa pine type.

REVIEW OF PAST WORK: Twenty-five study plots involving five intensities of thinning were established in ponderosa pine sapling stands in 1934. Small demonstration areas involving both thinnings and pruning have been established in 1934, 1935, 1936, and 1937. A study of natural pruning rate and branching habit of ponderosa pine was begun in 1935 and field work completed in 1936. A comprehensive time-cost study of pruning 800 trees to a height of 17 feet involving variables in tools, tree size, and numbers and size of live and dead limbs was made in 1936.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) A check of snow injury to crop trees in ponderosa pine sapling and pole thinnings showed that damage in the third winter following thinnings was negligible. During the first two winters the "weak sisters" had apparently passed out of the picture (more than 15 percent of the crop trees in the 2-inch diameter classes having been injured on some plots), and while it is possible that very severe snow conditions would still inflict material damage, no such losses are expected as occurred in the first two winters. While extent of damage has been greater in the smaller diameter classes, so has also recovery of injured trees. Initial snow damage in young thinnings should not be regarded serious as the number of uninjured crop trees will be more than sufficient to form a full stand at the end of rotation, barring fire, insects, and other acts of God. (b) A study on the amount of degrade and the rate of healing of limb scars from pruning on butt logs was initiated during 1937. This study involves four diameter classes of trees, and open south aspect and dense north aspect timber. The mean annual radial growth at d.b.h. was determined for all sample trees and showed this growth to be 0.048 inch for north aspect trees, 0.098 inch for south aspect trees. This difference appears sufficiently great to affect healing time, though the advantages of south aspect trees will be somewhat offset by their having the larger scars.

(c) A pruning time study was conducted in 30- to 40-year-old stands and confined to the butt log of trees 5, 6, and 7 inches in d.b.h. Several types of tools were tested. The net time (average for all tools) to prune the butt log amounted to 3.52, 3.95, and 4.66 minutes for 5-, 6-, and 7-inch trees respectively. For the 5-inch d.b.h. trees the mean total height was 35 feet, mean height to average live crown 19.5 feet, and mean height to lowest live limb 15.1 feet. On the basis of these measurements it is adjudged that on most central Idaho sites, only an occasional crop tree below the 4-inch diameter class can be pruned at once to a height of 17 feet without inducing a considerable falling off in radial growth through reduction of the green crown.

PLANS FOR NEXT YEAR: (a) The analyses on the 1936 and 1937 pruning time - cost studies will be completed and reports issued. (b) Snow damage in the young thinned stands will again be determined.

DATE OF COMPLETION: (a) A progress report on the 5-year check of the young thinning will be prepared in 1939; growth and mortality phases of this study indefinite. (b) Degrade and healing rate study - indefinite.

ASSIGNMENT: T. E. Maki.

RS - INT
M-1, R

March 15, 1938

NATURAL REPRODUCTION OF PONDEROSA PINE

FIELD DIVISION: Forest Management.

FUNCTIONAL PROJECT: Silviculture. (WORK PROJECT: Silvicultural Investigations.)

SUBPROJECT: Natural Regeneration. (LINE PROJECT: Natural Regeneration.)

PURPOSE OF WORK: To determine factors and conditions affecting natural reproduction of ponderosa pine from the flower stage of seed development through to the mature seedling. Three distinct yet interrelated phases are involved: (1) seed supply and distribution - a determination of quantity, quality, and the factors affecting both; (2) physical and biotic factors pertaining to germination and seedling establishment; and (3) factors pertaining to subsequent survival and growth.

REVIEW OF PAST WORK: An informal study of cone development, from the flower stage to maturity, was begun in 1935. Cone crops of 1,500 trees on permanent sample plots have been recorded for the past 4 years. An intensive study of quantity and quality of seed as related to character of individual seed tree, particularly its Dunning tree class, was made in 1936. Seed distribution is being studied by means of seed traps in virgin, cut-over, and second growth stands. During 1936 and 1937 the factors affecting seed germination and seedling establishment were measured on a series of seeded plots in rodent-proof and stock-proof exclosures on a north, south slope, and flat site. The heavy seed crops of 1934 and 1936 afforded opportunity for extensive determinations (transect studies) of the effects of soil, aspect, cover, etc. upon establishment and first-year mortality of seedlings under entirely natural conditions. Further data on survival and growth of native seedlings are being obtained from annual examination of transects on methods-of-cutting plots.

ACCOMPLISHMENTS DURING THE PAST YEAR: Both cone crop records and catch of seed in traps have shown that in good years, such as 1934 and 1936, there is no dearth of total seed supply reaching the ground. The total ponderosa pine seedfall of 1936 as determined from traps averaged 173,000 per acre in virgin forest, 307,000 in selectively cut stands, and 160,000 in second-growth stands. This resulted in 1937 in the germination of 2,966 seedlings per acre in virgin forest and 5,052 per acre on selectively cut areas. Of these initial numbers of seedlings, only 93 and 558 respectively survived at the end of the year.

As in other regions, rodents were found to account in large measure for the consumption of seed and to a lesser degree the destruction of new seedlings. Insolation and drought were the important physical causes of high mortality. Drought kill was much greater under natural conditions than in the exclosure seedbeds, presumably because of the elimination of plant competition in the latter.

PLANS FOR NEXT YEAR: Analysis of seed supply and other accumulated data will be completed, and annual inventories of cone crops, seedfall, and natural seedlings will be made. The study of physical factors under partial control in the exclosures will be continued through 1938. Major attention will be given to a study of relations of plant competition, shade, and aspect to seedling establishment, involving seedling observations and physical factor measurements on a series of 96 paired plots, artificially seeded in the fall of 1937.

DATE OF COMPLETION: Seed production studies: (a) quantity - 1944; (b) quality - after next good seed year. Factor studies - 1940. Natural survival and growth (intensive seasonal measurements) - 1940. Partial results are being obtained currently from all phases, with consequent narrowing down of field of study from year to year; should be of minor importance after about 1940.

ASSIGNMENT: E. L. Mowat.

RS - INT
M-1
(B-Phenology)

March 15, 1938

FOREST PHENOLOGY (PONDEROSA PINE TYPE)

FIELD DIVISION: Forest Management.

FUNCTIONAL PROJECT: Silviculture. (WORK PROJECT: Silvicultural Investigations.)

SUBPROJECT: Forest Phenology. (LINE PROJECT: Forest Phenology.)

PURPOSE OF WORK: To determine the time and progress of vegetative growth, flowering, fruiting, leaf fall, and other phenological events for the common forest trees and certain associated key species to lower vegetation of the Boise Basin Experimental Forest; to correlate these observations and measurements with climatic data; and to develop and encourage the use of this information as an aid or index in growth, reproduction, and other investigations or in practices of forest and range administration.

REVIEW OF PAST WORK: A schedule of observations begun in 1935 were revised and systematized in 1936 to allow of statistical analysis of results. Weekly measurements were made on 10 specimens each of two grasses, two herbs, and two shrubs at three elevations. Supplementary general observations were recorded for several other common species. Measurements of current diameter growth of 60 trees (ponderosa pine, Douglas fir, alpine fir, and aspen), and current height growth of 35 saplings (ponderosa pine, Douglas fir, and alpine fir) were made weekly through the growing season.

ACCOMPLISHMENTS DURING THE PAST YEAR: Observations continued; no analysis.

PLANS FOR NEXT YEAR: Data will be analyzed and correlated with weather records and results of interest reported. Observations will be continued on a similar scale through 1938 and indefinitely.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: E. L. Mowat.

RS - INT
Fs

March 15, 1938

PONDEROSA PINE SEED

FIELD DIVISION: Forest Management

FUNCTIONAL PROJECT: Artificial Regeneration. (WORK PROJECT: Regeneration Investigations.)

SUBPROJECT: Seed Studies. (LINE PROJECT: Seed Studies.)

PURPOSE OF WORK: To develop for ponderosa pine seed a body of information which will serve as a guide in seed collection, extraction, and storage practices.

REVIEW OF PAST WORK: During 1936 a scheme utilizing the specific gravity of freshly gathered cones was developed for predicting seed maturity. Ponderosa pine cone characteristics and yield and quality of seed were determined from 150 sample trees representing two age classes, two altitudinal ranges, and two degrees of stand density. Storage tests involving seven sources of seed at six different conditions of storage were also initiated.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) Further trials of the cone specific gravity scheme of predicting seed maturity indicated that a test liquid of a half and half mixture of linseed oil and kerosene would be suitable for central Idaho conditions. Cones floating in this liquid (density about 0.86 gram per cm^3) may be regarded as sufficiently mature to obviate any appreciable losses in seed quality. The specific gravity of the fresh cones as an index of maturity proved considerably more reliable than ocular estimates. Cone collections made early in the season materially reduced the germinative energy of seed, even August 16 lots exhibiting a germinative energy of only 50 percent as compared to 75 percent for the September 5 lots. (b) Laboratory cutting and float tests and greenhouse germination tests showed that young trees (about 60 years old) from more or less normal stands yielded seed of significantly higher germinative capacity than the same age open grown trees and also higher than mature and overmature trees. Differences between young and old trees amounted to about 10 percent in germinative capacity. Altitude was also a significant source of variation, trees from 5,500 feet yielding lower quality seed than trees from 4,000 feet. (c) Seed from three conditions of storage were subjected to germination tests during June ($8\frac{1}{2}$ months after extraction and storage). These three conditions comprised: (1) Above ground cellar storage - "constant" temperature between 32° and 50°F. (2) Shop storage -

fluctuating temperatures, with extremes from -40°F. to +80°F. (3) Outside storage in glass containers receiving sunlight - fluctuating temperatures from -40°F. to +80°F. Cellar stored seed showed a significantly higher germinative energy percentage (15 days after sowing), but the differences in final germination (25 days after sowing) were not significant.

PLANS FOR NEXT YEAR: (a) Germination tests on storage lots will be continued.

DATE OF COMPLETION: Tests on storage lots will be continued annually until 1943.

ASSIGNMENT: T. E. Maki and E. L. Mowat.

RS - INT
Fn

March 15, 1938

PONDEROSA PINE NURSERY CULTURE

FIELD DIVISION: Forest Management.

FUNCTIONAL PROJECT: Artificial Regeneration. (WORK PROJECT: Regeneration Investigations.)

SUBPROJECT: Nursery Culture. (LINE PROJECT: Nursery Culture.)

PURPOSE OF WORK: To test and develop methods of nursery practice which will result in the production of forms of planting stock giving better field survival at a minimum final cost.

REVIEW OF PAST WORK: The Bannock Creek experimental nursery was established in the fall of 1935. Improvements added in 1936 included a diversion dam, tool-house, and rodent-proof fence. A few beds sown to ponderosa pine in June 1936 yielded preliminary information on watering and protection requirements. In October 1936 two ponderosa pine seedbed experiments were initiated, one involving variables of mulch treatment and season of sowing, and the other involving frequency of watering, season of sowing and seed source.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) Fall sowing of ponderosa pine is superior to spring sowing from the standpoint of both germination and seedling development. The mean number of seedlings (all grades) per 4 x 12 bed at the end of the first growing season was 3,740 for fall-sown beds and 1,940 for spring-sown beds. Part of this difference is due to hold-over germination in the latter beds and part due to the more severe bird (principally mourning dove) and mice depredations in the early summer. At the end of the first growing season mean oven-dry weight of seedling (medium grade) was 603 milligrams for fall-sown as compared to 301 milligrams for spring-sown seedlings. Mean root length of the same grade of seedlings was 23 inches and 16 inches and mean top length 3.3 inches and 2.2 inches for the fall and spring-sown stock respectively. Summer (July) sowings were practically a complete failure. Counts made in October 1937 on June 1936 sowings showed a delayed germination of some 30 percent of the total numbers present in October 1936.
(b) Three frequencies of watering [(1) heavy = 3/4 inch of rain every 4 days; (2) medium = 3/4 inch of rain every 10 days; and (3) light = 3/4 inch of rain only once during the entire growing season] showed no significant differences with respect to total numbers of seedlings surviving at the end of the first growing season, but did introduce significant differences in

general appearance and size of seedlings, particularly the tops. Mean oven-dry weight of top (medium grade) was 277 milligrams and 186 milligrams for the heavy and light waterings respectively; likewise mean length of tops was 3.31 inches and 2.44 inches respectively. Mean root lengths were 23 inches and 22 inches respectively for this same grade of seedling. (c) In fall sowing use of mulches introduced no significant difference in seedling survival but helped materially in moisture conservation. Seven days after watering, the mean moisture content of the surface foot of soil in the bare beds was 5.95 percent as compared to 11.75 percent in the aspen mulch beds. In spring sowings, mulches exercised an additional protective effect, especially against bird depredations. Mean number of seedlings in the unprotected 4' x 12' beds was 2,330 as against a mean of 5,060 for those protected by various mulches.

PLANS FOR NEXT YEAR: (a) Studies on the protective and other effects of mulch will be continued. (b) Root pruning and transplanting studies will be initiated. (c) Cooperative investigations with the McCall and Tony Grove nurseries will be given consideration.

DATE OF COMPLETION: (a) Frequency of watering study will be carried through the transplant stage (3 years). (b) Mulch studies will be continued for 2 more years. (c) Other studies - indefinite.

ASSIGNMENT: T. E. Maki.

RS - INT
Fp

March 15, 1938

FIELD PLANTING

FIELD DIVISION: Forest Management

FUNCTIONAL PROJECT: Artificial Regeneration. (WORK PROJECT; Regeneration Investigations.)

SUBPROJECT: Planting Investigations. (LINE PROJECT: Planting Investigations.)

PURPOSE OF WORK: To determine by study of experimental plantings the factors of site, source, age, and treatment of stock responsible for good and poor survival in order to develop planting technique and criteria of site selection that will insure greater success in reforestation of burns and other areas within the Intermountain region.

REVIEW OF PAST WORK: Test plantings of ponderosa pine were initiated in 1934 in central Idaho followed by replantings in 1935 and 1936. A report issued in 1935 indicated the gross relationship of slope, aspect, soil, shade, etc. to seedling survival.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) The coding and machine compilation of the 1934, 1935, and 1936 data were completed. (b) Test plantings of ponderosa pine and Douglas fir were initiated in the spring of 1937. Although survival was exceedingly poor owing to prolonged drought in May plus drastic July and August weather, certain relationships nevertheless are indicated by these tests. Survival for all plantations ranged from 3 percent to 64 percent. In using the center hole method, planting in deep holes 18 inches deep (equivalent to subsoiling) significantly increased survival over planting in shallow holes (10 inches deep.) In the ponderosa pine age-of-stock depth-of-hole trials the mean survival, all aspects, was as follows: 28.6 percent for 2-2 deep hole; 25.0 percent for 2-0 deep hole; 21.3 percent for 2-2 shallow hole; 20.0 percent for 2-0 shallow hole. Mean survival by aspects in the same test was 9.7 percent on southerly, 29.0 percent on northerly, and 35.2 percent on draw aspects. In the species depth-of-hole trials, ponderosa pine was decidedly better than Douglas fir, 1-2 ponderosa pine having a mean survival of 48.0 percent (all aspects combined) for deep holes, 41.5 percent for shallow holes as compared to same age Douglas fir survival of 23.8 percent and 21.9 percent for the deep and shallow holes respectively. (c) An experiment involving fall and spring planting, shade and no shade, root pruning and no pruning was initiated in the fall of 1937.

PLANS FOR NEXT YEAR: (a) The spring planting of the season-of-planting tests will be made. (b) A progress report on the machine compiled planting data of 1934, 1935, and 1936 will be prepared. (c) Cooperative planting studies with the region will be undertaken.

DATE OF COMPLETION: (a) The comprehensive analysis of all past trial plantation data will be completed by 1940. (b) Season of planting, type of stock, etc., studies indefinite. (c) Yearly survival and growth phases - indefinite.

ASSIGNMENT: T. E. Maki and E. L. Mowat.

RS - INT
Fp
Artificial Seeding March 15, 1938

ARTIFICIAL SEEDING OF PONDEROSA PINE

FIELD DIVISION: Forest Management.

FUNCTIONAL PROJECT: Artificial Regeneration. (WORK PROJECT: Regeneration Investigations.)

SUBPROJECT: Artificial Seeding. (LINE PROJECT: Artificial Seeding.)

PURPOSE OF WORK: To test the efficacy of artificial seeding as a method of restocking burns and other areas and to compare final costs of seeding with those of planting.

REVIEW OF PAST WORK: The first artificial seeding of ponderosa pine was initiated on the Elk Creek burn in November, 1935. First season survival of 65 percent in the spots protected by 1/2-inch hardware cloth cages led to additional tests started in the fall of 1936 involving paired spots sown without protection and with window screen tube protection in fall and spring sowings.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) Both early summer and autumn checks showed the screen tubes afforded excellent protection for seed and seedlings, but mortality from heat and drought was so severe that the test areas, except on north slopes, were almost complete failures. (b) The tests further indicated that seed sown in the spring in central Idaho did not have an opportunity to germinate because of the rapid drying of surface soils. Since only in exceptionally wet years would spring sowings succeed, artificial seeding in central Idaho should be attempted only in the fall. (c) An experiment involving the use of 1/3-inch mesh hardware cloth cones and cages with two degrees of shade was started in the fall of 1937.

PLANS FOR NEXT YEAR: (a) The germination and survival of the seedlings in the autumn 1937 study will be followed throughout the growing season. (b) Cooperative studies with the region will be undertaken to test the effectiveness of direct seeding under a wider range of conditions.

DATE OF COMPLETION: (a) Technique tests - 1943 except for recurring survival and growth checks. (b) Cooperative studies - indefinite.

ASSIGNMENT: T. E. Maki and E. L. Mowat.

RS - INT
ME

March 15, 1938

INDIVIDUAL TREE STUDIES

FIELD DIVISION: Forest Management.

FUNCTIONAL PROJECT: Mensuration. (WORK PROJECT: Mensuration.)

SUBPROJECT: Individual tree studies. (LINE PROJECT: Individual tree studies.)

PURPOSE OF WORK: To obtain and present information upon the form, volume, and growth of individual trees, as may be needed for forest management and for the conduct of other studies relating thereto.

REVIEW OF PAST WORK: This broad and flexible field of study includes such tree measurements and analyses as are made from time to time in the preparation of volume and taper tables and similar mensurational data. To date relatively little work has been done by this station except as incidental to methods-of-cutting and other studies of ponderosa pine and associated species. Local volume tables for small ponderosa pine and Douglas fir in Boise Basin were prepared in 1934. An alinement chart for conversion of stump d.i.b. to d.b.h.o.b. of ponderosa pine was also made.

ACCOMPLISHMENTS DURING THE PAST YEAR: None (suspended).

PLANS FOR NEXT YEAR: No new work contemplated for coming year; project kept open until facilities allow further work in this field. Tentative plans include investigation of tree-class volume tables for ponderosa pine, and preparation of regional tables for minor species.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: T. E. Maki and E. L. Mowat.

RS - INT
ME

March 15, 1938

PONDEROSA PINE STAND STUDIES

FIELD DIVISION: Forest Management.

FUNCTIONAL PROJECT: Mensuration. (WORK PROJECT: Mensuration.)

SUBPROJECT: Stand Studies. (LINE PROJECT: Stand Studies.)

PURPOSE OF WORK: To determine the structure, volume, growth, yield, and mortality of forest stands and factors pertaining thereto for use in plans and practices of forest management. (Work to date confined to ponderosa pine type.)

REVIEW OF PAST WORK: Growth of virgin ponderosa pine stands on the Payette National Forest has been measured on 13 permanent sample plots since 1913; last complete analysis and report in 1935. One such plot was established on the Boise Basin Experimental Forest in 1935. Measurements of 43 sample plots of evenaged second-growth ponderosa pine were made in 1934 as part of the interregional study of yields of such stands. The timber survey of the experimental forest in 1933-34 furnished detailed information on structure and volume of virgin and cut-over stands, and the semipermanent layout of cruise plots provides for future extensive measurements of mortality and increment. Special annual surveys are being made of the experimental forest to determine mortality from bark beetle attack - a question of major importance in this type.

ACCOMPLISHMENTS DURING PAST YEAR: The bark beetle survey of 1937 indicated an average annual loss of ponderosa pine during the past 2 years of 110 trees, or 169,107 bd.ft. on 2,182 acres of virgin pine type. This is equivalent to 0.6 percent of the total volume of the stand. The average loss per acre is about the same as the mean annual loss from this cause on the Payette plots during the period 1913-31.

PLANS FOR NEXT YEAR: Annual bark beetle survey. No major work scheduled until virgin plot remeasurements in 1941.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: T. E. Maki and E. L. Mowat.

RS - INT
Pf

March 15, 1938

EFFECTS OF FIRE IN PONDEROSA PINE FORESTS OF CENTRAL IDAHO

FIELD DIVISION: Forest Management.

FUNCTIONAL PROJECT: Fire Protection. (WORK PROJECT: Fire Protection Investigations.)

SUBPROJECT: Effects of Fire. (LINE PROJECT: Effects of Fire.)

PURPOSE OF WORK: To determine the after-effects of fire in terms of the subsequent growth and mortality of surviving trees, the rate and success of natural regeneration, and the succession of vegetation on burned areas.

REVIEW OF PAST WORK: The original study was initiated in 1932, with the broader object of measuring the nature and extent of all forms of fire damage to the forest. Results were published in 1935 in two major reports, dealing with damage to the stand and with erosion relationships. The remaining phase of the study is a follow-up to determine delayed effects and further changes that will complete the picture of fire influence and aid in the management of burned areas.

ACCOMPLISHMENTS DURING THE PAST YEAR: Complete 5-year remeasurements of sample plots in fire-injured stands show a variable but generally serious subsequent loss of trees, chiefly from bark beetle attack. The heavy attack had largely subsided at the end of 5 years, but occasional trees were still dying. Growth of living trees has been slow; foliage on green portions of crowns is about normal again but total crown area was permanently reduced by the fire. Where the stand was not entirely killed, an average of 202 new seedlings per acre was present at the end of the second year following the fire, and their survival and growth has been fair. Later seeding in has been very sparse; until 1937 insufficient to offset mortality. Most portions of the burned area have been revegetated with a heavy cover of shrubs and weeds and are rapidly assuming the familiar aspect of an old-burn "brush field." In general, the vegetation density, as determined on 15 transects, is already twice as heavy as that of the ground cover in corresponding virgin forest. Specific figures on these and other results of the study await further analysis of the data.

PLANS FOR NEXT YEAR: Data will be compiled and a progress report prepared to summarize results of the study to date.

DATE OF COMPLETION: Indefinite. First progress report, 1938.

ASSIGNMENT: T. E. Maki and E. L. Mowat.

RS - INT
Pf

March 15, 1938

FIRE PRESUPPRESSION AND BEHAVIOR

FIELD DIVISION: Forest Management.

FUNCTIONAL PROJECT: Fire Protection. (WORK PROJECT: Fire Protection Investigations.)

SUBPROJECT: Fire Presuppresion and Behavior. (LINE PROJECT: Fire Presuppression and Behavior.)

PURPOSE OF WORK: To assist the Regional Office primarily in the testing and perfecting of various devices and schemes, particularly wood cylinders and duff hygrometers, used in measuring fuel moisture and predicting fire danger.

REVIEW OF PAST WORK: Beginning in 1932 the station has directed a study testing wood cylinders and duff hygrometers on an experimental scale on the "fire forests" of central Idaho, in an effort to supplement existing schemes of fire danger prediction. The results have been compiled and a report prepared for region-wide distribution each year.

ACCOMPLISHMENTS DURING THE PAST YEAR: (a) A compilation of the 5-year records of wood cylinders was made and a report prepared for distribution to the various forests in the region. (b) Plans were made for calibration of wood cylinders and few duff hygrometers for the region. As a corollary, the Region has decided definitely to include wood cylinder measurements of fuel moisture in their scheme of fire danger prediction and has expanded the numbers from the experimental scale of five in 1936 to a working basis of more than a hundred sets for the coming fire season.

PLANS FOR NEXT YEAR: (a) Wood cylinders and duff hygrometers will be calibrated.

DATE OF COMPLETION: Indefinite.

ASSIGNMENT: T. E. Maki and E. L. Mowat.

APPENDIX

R - INT
Investigative Program
and Report

STATION PERSONNEL - C.Y. 1937

ADMINISTRATION

Regular

Reed W. Bailey	Director	P-6
Walter E. Mann	Adm. Assistant	CAF-8
Marguerite A. Israelson	Clerk	CAF-4
Herbert Burrell	Clerk	CAF-4
Leona H. O'Donnell	Asst. Clerk	CAF-3
Hazel Brown	Sr. Stenographer	CAF-3
Signe Ruh Otterson	Jr. Librarian (Coop. R-4)	P-1

Temporary

Zura Gerdicia	Sr. Stenographer	CAF-3
Willard M. Chase	Asst. Clerk	CAF-3

RANGE INVESTIGATIONS

Grazing Management

Regular

George Stewart	Sr. Forest Ecologist	P-5
Joseph F. Pechanec	Assoc. Forest Ecologist	P-3
Raymond Price	Assoc. Forest Ecologist	P-3
Selar S. Hutchings	Asst. Forest Ecologist	P-2
Ira Clark	Asst. Conservationist	P-2
Lowell Woodward	Jr. Range Examiner	P-1

Temporary

Arnold Heerwagen	Jr. Range Examiner	P-1
Ralph Stocking	Asst. Technician	SP-4
Arthur H. Holmgren	Jr. Field Assistant	SP-3
Lamont R. Shelby	Jr. Field Assistant	SP-3
Hosmer Ray Bjarnson	Jr. Asst. Technician	SP-1
Bernard C. Christensen	Jr. Asst. Technician	SP-1
Reed Huff	Jr. Asst. Technician	SP-1
Eldon Earl Meik	Jr. Asst. Technician	SP-1

Artificial Reseeding

Regular

Rudger H. Walker	Conservationist	P-4
Alvin C. Hull	Jr. Range Examiner	P-1

Temporary

Albert L. Klingebiel	Jr. Technologist	P-1
Perry Plummer	Jr. Range Examiner	P-1
Henry E. Peterson	Asst. Technician	SP-4
Joe M. Cutler	Jr. Asst. Technician	SP-1

LAND RESOURCES

Western Range Survey

Regular

Walter P. Cottam	Conservationist	P-4

Temporary

Byron F. Thurmond	Surveyor-Draftsman	SP-7
Paul S. Bieler	Sr. Eng. Draftsman	SP-6
Harold W. Francom	Sr. Eng. Draftsman	SP-6
Mont Swenson	Jr. Field Assistant	SP-3
Reed Thomson	Jr. Field Assistant	SP-3
Verd P. Hancock	Under Field Assistant	SP-2
Golamae Johnson	Under Clerk Typist	CAF-1

FOREST ECONOMICS

Range Economics

Regular

George Stewart (Acting)	Sr. Forest Ecologist	P-5

Temporary

Douglas E. Henriques	Jr. Field Assistant	SP-3
Durrell E. Evans	Under Field Assistant	SP-3

FOREST INFLUENCES

Watershed Factors, Utilization and Control

Regular

G. W. Craddock	Sr. Range Examiner	P-5
A. Russell Croft	Assoc. Conservationist	P-3
C. Kenneth Pearse	Assoc. Range Examiner	P-3

Temporary

Maurice W. March	Jr. Range Examiner	P-1
Howard E. Petersen	Jr. Range Examiner	P-1
A. Riggs Murdock	Asst. Technician	SP-4
Reuben I. Campbell	Jr. Engineering Aide	SP-3
Howard R. Foulger	Jr. Field Assistant	SP-3
Lemuel H. Thompson	Jr. Assistant Tech.	SP-1
Neil Wilcox	Jr. Assistant Tech.	SP-1
Harry W. Pledger	Foreman C.& M	CU-7

FLOOD CONTROL SURVEYS

Watershed Surveys

Regular

George W. Craddock	Sr. Range Examiner	P-5

FOREST MANAGEMENT

Regular

T. Ewald Maki	Asst. Forester	P-2
Edwin L. Mowat	Asst. Silviculturist	P-2

Temporary

Dean C. Rowland	Jr. Forester	P-1
Edmund L. Barraclough	Jr. Asst. Technician	SP-1

R - INT
Investigative Program
and Report

PUBLICATIONS

A. Publications during the calendar year 1937.

I. Departmental Publications (U.S.D.A.)

Range Investigations

(1) Craddock, George W., and Forsling, C. L.
The influence of climate and grazing on spring-fall sheep range in southern Idaho. U.S.D.A. Technical Bulletin 600. (In hands of printer.)

(2) McCarty, Edward C.
1938. The relation of growth to the varying carbohydrate content in mountain brome. U.S.D.A. Technical Bulletin 598. (24 pp.)

(3) Pechanec, Joseph F., and Pickford, G. D.
1937. A comparison of some methods used in determining percentage utilization of range grasses. Jour. Agr. Res. 54:753-765.

(4) Price, Raymond, and Evans, Robert B.
1937. Climate of the west front of the Wasatch Plateau in central Utah. Monthly Weather Review 65:291-301.

Forest and Range Influences

(1) Bailey, Reed W., and Croft, A. R.
1937. Contour-trenches control floods and erosion on range lands. ECW Forestry Publication No. 4.

(2) Craddock, George W., and Pearse, C. Kenneth.
Surface run-off and erosion on granitic mountain soils of Idaho as influenced by range cover, soil disturbance, slope, and precipitation intensity. U.S.D.A. circular. (In hands of printer.)

II. Outside Publications (in scientific and professional journals, etc.)

Range Investigations

(1) Pechanec, Joseph F., Pickford, G. D., and Stewart, George. 1937. Effects of the 1934 drought on native vegetation of the upper Snake River plains, Idaho, Ecology 18:490-505.

(2) _____, and Pickford, G. D. 1937. A weight estimate method for the determination of range or pasture production. Jour. Amer. Soc. Agron. 29:894-904.

Forest and Range Influences

(1) Bailey, Reed W. 1937. A new epicycle of erosion, pp. 997-1005. Jour. Forestry, Vol. 35, No. 11.

(2) Craddock, George W. 1937. Prospective foresters and the problems of mountain water. Forestry Club Annual, University of Idaho Southern Branch.

(3) Croft, A. R., Woodward, Lowell, and Anderson, D. A. 1937. Comparison of accelerated erosion losses in Emigration, Red Butte, and City Creek Canyons, pp 31-32, Utah Academy of Sciences, Arts and Letters, Volume XIV.

(4) Woodward, Lowell, and Anderson, D. A. 1938. A device for the rapid collection of surface-inch soil samples, pp. 162-163, Jour. Amer. Soc. Agron. Vol. 30, No. 2.

(5) Station Staff 1938. Graphic instruments in the study of run-off and erosion, illus., pp. 295-297, Graphic Routes to Greater Projects. Esterline Angus Co.

III. Miscellaneous Mimeographed Reports.

(1) Pearse, C. Kenneth, and Bertelson, F. Dwight. 1937. The construction and operation of an apparatus for the measurement of absorption of surface water by soils. Mimeo. 10 pages, 1 figure, 3 plates.

(2) Stewart, George, Walker, R. H., and Price, Raymond. Procedure in reseeding range lands of the Intermountain Region, 12 pp.

(3) Program of Second Field Day, September 3 and 4, 1937, at the Desert Range Branch Station, 20 pp.

B. Departmental publications scheduled for the remainder of the fiscal year 1938.

Range Investigations

(1) Costello, David F., and Price, Raymond. Climate and plant development in relation to range management. To be published as U.S.D.A. Technical Bulletin _____.

(2) Price, Raymond. Artificial reseeding on oakbrush range in central Utah. To be published as U.S.D.A. Bulletin _____.

(3) Stewart, George, Walker, R. H., and Price, Raymond. Procedure in reseeding range lands of the Intermountain region. U.S.D.A. Circular. (Ready and awaiting publication.)

C. Manuscripts intended for departmental publication during the fiscal year 1939.

Range Investigations

(1) McCarty, Edward C., and Price, Raymond. Growth and carbohydrate food ratios of important range forage plants and their reactions to clipping and grazing treatments. To be published as U.S.D.A. Technical Bulletin _____. (32 pp., 10 illus.)

(2) Pechanec, Joseph F. Analysis of covariance in range research. Manuscript completed and in process of final revision. For publication in Jour. of Agr. Res. (20 pp., 4 illus.)

(3) _____, and Stewart, George. Sampling problems in range research -forage inventory. In preparation. For publication in Jour. Agr. Res. (30 pp., 10 illus.)

(4) _____, Effect of sagebrush fires on soil properties. Note for Soil Science. In process of preparation.

(5) Price, Raymond, and _____.
The relation of season, frequency and degree of harvesting to the productivity, revegetation and vigor of the vegetation. (Subproject title of investigations which include browse clipping studies.) (To be prepared.)

(6) Stewart, George, Pickford, G. D., and Pechanec, Joseph F.
Effect of sagebrush removal by fire on native spring-fall range in southeastern Idaho. Manuscript in process of final revision. For publication in Jour. of Agr. Res. (30 pp., 12 illus.)

(7) _____, Walker, R. H., and Hull, A. C., Jr.
Adaptation of forage species and low-cost methods for artificially reseeding range lands in Utah and Nevada. U.S.D.A. Bulletin (32 pp., 10 illus.) (To be prepared.)

(8) _____, Cottam, W. P., and Hutchings, Selar S.
Influence of unrestricted grazing on plant associations of desert valleys in western Utah. For Jour. of Agr. Res. (Edited, revised, and returned to Washington.)

(9) _____, and Hutchings, Selar S.
Improvement of winter ranges as influenced by various intensities of grazing. U.S.D.A. Bulletin. (32 pp., 10 illus.) (To be prepared.)

(10) _____, and Hutchings, Selar S.
Palatability of desert vegetation as influenced by climate, season of use and composition of plant cover. Jour. Agr. Research (20 pp., 6 illus.) (To be prepared.)

Forest Management

(1) Maki, T. E.
Root development of ponderosa pine seedlings. For publication in Jour. of Agri. Research. (15 pp., 5 illus.) (To be prepared.)

(2) _____, and Mowat, E. L.
Survival and growth of ponderosa pine in central Idaho plantations. Jour. of Agri. Research (30 pp., 10 illus.) (To be prepared.)

R - INT
Investigative Program
and Report

STATION BUDGET - F.Y. 1938
INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
Direct & Indirect Costs by Divisions

Division	Indirect project costs (overhead)	Direct project costs	Total costs
Forest Management	$ 660	$ 6,740	$ 7,400
Range Investigations	6,096	45,054	51,150
Land Resources (WRS)	1,848	11,452	13,300
Forest Economics	2,200	11,000	13,200
Forest & Range Influences	1,534	13,516	15,050
Flood Control Surveys	924	7,076	8,000
S & E Improvement, R-4 (All Divisions)	0	5,400	5,400
TOTALS	$13,262	$100,238	$113,500

Distribution of Direct Costs by Main Projects

Division and work project	Purchase & maintenance cars	Scient. equip. & supplies	Travel expense other than cars	Salaries Regular	Salaries Temporary	Total
Forest Management						
All Projects	$ 261	$ 358	$ 215	$ 5,726	$ 180	$ 6,740
Range Investigations						
Grazing Management	1,643	2,054	1,603	17,208	4,959	27,467
Artificial Reseeding	925	2,360	1,093	11,696	1,513	17,587
Western Range Survey	535	346	1,071	2,853	6,647	11,452
Forest Economics						
Range Economics	1,579	864	1,503	3,044	4,010	11,000
Forest & Range Influences						
Water Factors, Utilization & Control	765	1,345	312	9,852	1,242	13,516
Flood Control Surveys						
Watershed Surveys	400	300	1,048	1,536	3,792	7,076
TOTALS	$6,108	$7,627	$6,845	$51,915	$22,343	$94,838